Motorpact™ Medium Voltage Motor Controller
Application Guide
Class 8198

Data Bulletin

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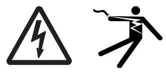
Retain for future use.

SQUARE D™

by Schneider Electric

Hazard Categories and Special Symbols

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service, or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER
DANGER indicates an imminently hazardous situation which, if not avoided, **will result in** death or serious injury.

WARNING
WARNING indicates a potentially hazardous situation which, if not avoided, **can result in** death or serious injury.

CAUTION
CAUTION indicates a potentially hazardous situation which, if not avoided, **can result in** minor or moderate injury.

NOTICE
NOTICE is used to address practices not related to physical injury. The safety alert symbol is not used with this signal word.

NOTE: Provides additional information to clarify or simplify a procedure.

Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

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Section 1–Introduction

Square D™ Motorpact™ Medium Voltage (MV) motor controllers provide control for 2300–7200 V induction (squirrel cage) motors, continuing our tradition of offering superior reliability combined with numerous operational benefits. These versatile controllers feature state-of-the-art vacuum technology with minimal current chopping (see “Section 5–Contactors” on page 18).

The Motorpact design reduces the number of internal electrical power connections, allowing for increased power throughput, reduced heat rise, and reduced controller maintenance.

Motorpact controllers have drawout contactors in one-high construction. The vacuum contactors are available in 200 A, 400 A, 450 A, and 720 A ratings, either electrically or mechanically held. Schneider Electric can provide indoor Type 1/1A (with gaskets), outdoor Type 3R, and arc-resistant enclosures.

The following types of applications are available in Motorpact:

- Induction (squirrel cage) motor, full-voltage non-reversing
- Induction (squirrel cage) motor, full-voltage reversing (200/400/450 A)
- Induction (squirrel cage) motor, reduced-voltage autotransformer
- Reduced-voltage soft start (RVSS)
- Sequential smart start (S3)
- Two-speed, one-winding controller
- Two-speed, two-winding controller

Each controller is designed and built to meet UL 347, NEMA ICS3, CSA, and IEC 60470. cULus labels are available. All controllers are manufactured under stringent ISO® 9001 standards.

This guide will assist you in applying Motorpact controllers to your motor control needs.

Section 2–Controllers

Choosing a controller depends on the load and the application. Motorpact controllers can be configured for motor starting, transformer feeders, capacitor feeders, or future spaces (full-voltage non-reversing only). The controllers provide complete front access on section widths greater than 14.75 in. (375 mm) wide, many personal protection features, and a wide range of applicable system voltages.

Figure 1: Full-Voltage Non-Reversing Controller

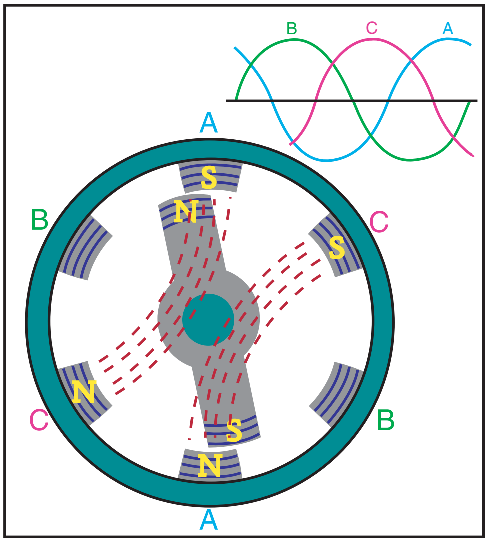
Figure 2: Full-Voltage Reversing Controller

Motor Starting

Motorpact controllers start induction (squirrel cage) motors using full voltage, full-voltage reversing, reduced voltage, or non-reversing methods.

An induction motor induces a voltage in the rotor, producing magnetizing currents. Since the stator field revolves, the rotor follows the stator (see Figure 3). However, the rotor never synchronizes, *i.e.,* reaches synchronous speed, with the stator field.

Figure 3: Induction Motor Operation

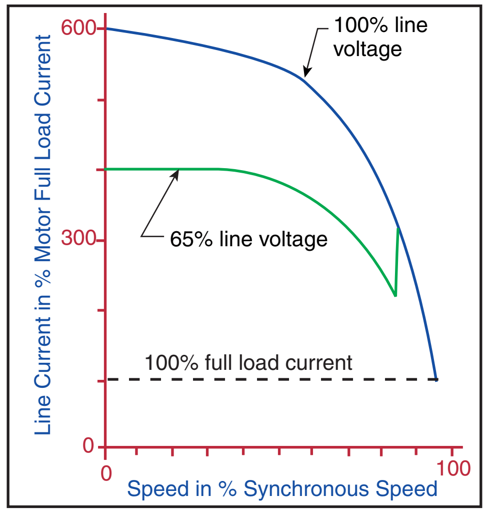


Full-Voltage Controllers

NOTE: The autotransformer will be shipped separately for horsepowers above 250. This is done to reduce the overall weight of the controller. The installer will be responsible for the correct installation of the transformer at the job site. For further instruction on the RVAT, see the "Field Installation" section in instruction bulletin no. 46032-700-06.

Full-voltage (or across-the-line) controllers apply the system line voltage to motor terminals to start a motor. The resulting inrush current can be high, ranging from 400% to 1000% of full-load current. Figure 4 shows the typical inrush current of 600%. Full-voltage starts also provide high-starting torque (about 150% of full load torque). Full-voltage controllers are the most widely used and meet most applications with their simple, cost-effective design.

Figure 4: Motor Starting Current



Reduced-Voltage Controllers

Utilities or equipment manufacturers may require reduced-voltage controllers. A utility may request reduced-voltage starting to limit the voltage drop during motor starting. Equipment manufacturers may suggest a reduced torque start for equipment driven by the motor. Reduced-voltage starting addresses both issues.

Starting with reduced voltage decreases the full load current (FLC) at the motor terminals in proportion to the voltage reduction, while the full load torque (FLT) is reduced by the square of the voltage reduction. For example:

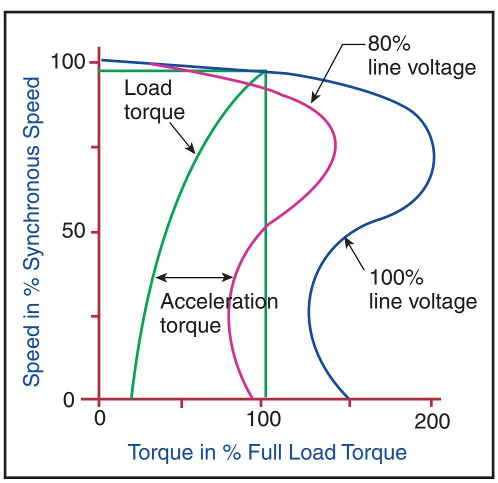
Voltage reduction = 65%

Motor current reduction = 65% X 600% FLC = 390% FLC

Torque reduction = $(65\%)^2$ X 150% FLT = 63% FLT

Figure 4 shows motor starting torque for a full voltage (100%) start and a reduced voltage (80%) start.

Figure 5: Motor Starting Torque



Reduced-Voltage Autotransformers

Reductions are accomplished with either an autotransformer or soft start. The autotransformer has three coils with 50%, 65%, and 80% taps. Each tap indicates the amount of voltage reduction provided. Controllers are shipped connected to the 65% tap as standard but can be set to the 50% or 80% tap upon request. Standard provided autotransformers are medium duty as defined by NEMA® ICS 9. These transformers are designed to operate per the duty cycle ratings in Table 1. In order to prevent transformer damage, these ratings must not be exceeded. Refer to NEMA ICS 9 for additional details. Heavy duty autotransformers are available for applications with acceleration times that exceed 30 seconds.

Table 1: Medium Duty Cycle Motor Ratings (201 to 3000 Horsepower, Inclusive)

On	30 seconds
Off	330 seconds
Repeat	2 times (for a total of 3 cycles)
Rest	1 hour

An autotransformer is the most popular device for reduced-voltage starting since it provides maximum starting torque with minimal line current. Due to transformer action, the line current will be 150%, 253%, and 384%, the motor current will be 300%, 390%, and 480%, and the starting torque will be 25%, 42%, or 64% of full voltage values for the 50%, 65%, or 80% taps, respectively.

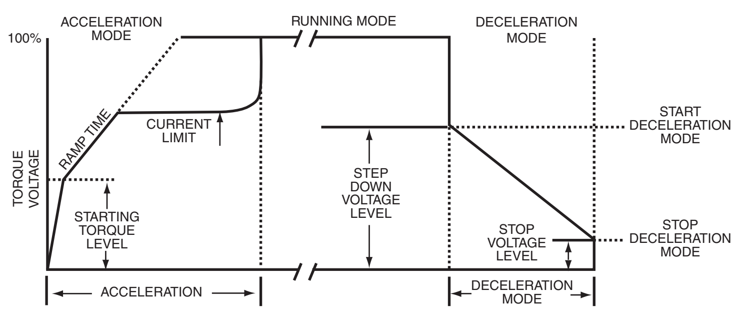
The two methods of transitioning from full voltage to reduced voltage are open and closed. Open transition disconnects the motor from the power source for a brief time, allowing the motor to act as a generator. However, once reconnected, both current and voltage transients are produced that may damage the motor. Motorpact controllers use the closed transition method, which means the motor is never disconnected from the power source during transition. Therefore, the motor is not subjected to the transient forces of an open transition.

The transition from full voltage to reduced voltage on Motorpact controllers is based on current and not time. An over-current relay monitors the motor current. As the motor approaches full load, the motor current drops below the preset value, the over-current relay de-energizes, and the controller transitions to full voltage (see Figure 4 on page 10). The preferred maximum for configuring the current transition relay to allow transitions is 120% motor full load amperes (the absolute maximum is 130% motor full load amperes). If the controller does not transition to full voltage in a preset time (rated acceleration time plus two seconds), an incomplete sequence relay signals the controller to stop. Do not configure the incomplete sequence relay for a time exceeding 30 seconds.

Reduced-Voltage Soft Starts

A second method of starting is with digital soft starts. The Motorpact reduced-voltage soft start (RVSS) is a three phase, microprocessor-based digitally controlled reduced-voltage soft starter for medium voltage AC motor applications. The unit controls the motor start-up by delivering an adjustable amount of initial voltage and current to the motor, then slowly increasing the voltage and current to 100%. The Motorpact RVSS has a linear voltage vs. time ramp, unless set up for current limit or ramp configuration (see Figure 6). This adjustable acceleration ramp allows a smooth transition to full motor speed from the point where the motor shaft begins to turn, regardless of the type of load.

Figure 6: Motor Acceleration and Deceleration Curves for Soft Starts



The Motorpact RVSS also features a selectable dual adjustment mode that can be programmed for a second load type. The Motorpact RVSS is offered in voltages from 2300 V to 7.2 kV, and current ratings from 100 to 400 A. Normally, soft starts are applied to unloaded motors. However, some applications can be considered if the torque requirements and time to accelerate to full speed will not exceed 600% current for greater than 30 seconds.

The acceleration ramp time for a typical start-up is 30 seconds or less, and is adjustable to allow the motor to smoothly accelerate the load. The current limit is adjustable from 100% to 600% of programmed motor full load amperage (FLA). This adjustment is separate from the acceleration time to allow greater control of peak power usage. At the end of the start cycle, the unit switches in a bypass contactor, placing the unit across the line with overload protection still present.

The Motorpact RVSS also features a central processing unit (CPU). Via programming, the CPU maximizes the performance and protection of the motor because it thermally models the motor. By measuring phase currents, negative sequence currents (due to any imbalance condition), and optional resistance temperature detector (RTD) feedback, the thermal model is defined by the motor manufacturer’s specifications. Thus, the thermal model is personalized to each individual motor and its operating limits.

The CPU divides the motor operation into modes according to functionality. Unique motor protection is provided in each of the four operation modes: Ready, Start, Run, and Stop.

Table 2: Motorpact RVSS SCR Pairs

	Voltage	Series Pairs	Total Number of SCRs	PIV Rating
200 and 400 A Units	2300 V	0	6	6500 V
	3300/4160 V	2	12	13,000 V
	6600/6900 V	3	18	19,500 V

The power section contains silicon controlled rectifier (SCR) power modules for each phase. They are matched devices arranged in inverse parallel pairs and in series strings to facilitate sufficient peak inverse voltage (PIV) ratings for the applied voltage. See Table 2 for the number of pairs provided in Motorpact RVSS starters.

Resistance capacitance (RC) snubber networks provide transient voltage protection for the SCR power modules in each phase to reduce dv/dt damage. The SCRs are gated (turned on) using a sustained pulse firing circuit. This circuitry is amplified and isolated from the control voltage by means of fiber optics for current and ring transformers.

Vacuum contactors are provided for both in-line isolation and as a soft start bypass. A sequencing feature controls the contactors. Under normal operating conditions this ensures that both contactors make and break under no-load conditions to maximize contactor life. Vacuum contactors are rated for the maximum starting requirement of the unit design. The bypass contactor is rated for emergency starting.

Soft starting can be applied to loads that you want to accelerate and decelerate to reduce adverse effects of starting and stopping. Applications such as pumping and conveyors are good examples of where soft starts are very beneficial. In a pumping application, the effects of “water hammer” can be detrimental to pipes, fittings, flanges, seals, and mounting systems. Conveyors can be started and stopped under control to avoid product damage due to sudden stops and starts.

NOTE: The RVSS offers very flexible starting, stopping, and protective features, therefore commissioning requires that the customer provides important data during the order process. The data required by the customer can be found in “Section 12–Commissioning” of instruction bulletin no. 46032-700-04. Start up service is available upon request.

See Table 3 on page 13 for a comparison of full voltage and reduced-voltage starting methods.

Table 3: Squirrel Cage Motor Starting Characteristics (In Percent of Full Load Values)

Controller Type	Voltage at Motor *	Line Current	Motor Current	Starting Torque	Limitations	Advantages
Across the line (full voltage)	100%	600%	600%	150%	Draws the highest current during starting, which affects: 1. LOAD: High starting torque results in sudden start for drive machine. May cause undue strain. 2. POWER SYSTEM CAPACITY: Limitations may prohibit high inrush current when starting a large motor at full voltage. 3. MOTOR LOCATION: Line voltage drop due to inrush current when the motor is located at a considerable distance from the power source may cause other controllers on the line to drop out.	1. Simplest controller type. 2. Least expensive and should be used when the limitations at left do not apply.
Primary reactor					1. Uses two contactors and a reactor, therefore it costs more and requires more space than full-voltage controllers. 2. Low power factor during starting.	1. Inherently closed transition type (motor is not disconnected from the line during transition from reduced-voltage starting to full-voltage running). 2. Voltage taps permit adjustment of starting voltage. 3. Suitable for long starting period.
50% tap	50%	300%	300%	25% (of 150%)		
65% tap	65%	390%	390%	42% (of 150%)		
80% tap	80%	480%	480%	64% (of 150%)		
Autotransformer					1. Uses three contactors and an autotransformer. Therefore, it costs more and requires more space than full-voltage controllers. 2. Low power factor during starting.	1. Provides highest torque per ampere of line current. 2. Inherently closed transition type (motor is not disconnected from the line during transition from reduced-voltage starting to full-voltage running), 3. Voltage taps permit adjustment of starting voltage. 4. Suitable for long starting period. 5. Motor current is greater than line current during starting which produces the same starting torque as in the primary reactor controller, but with reduced line current.
50% tap	50%	150%	300%	25% (of 150%)		
65% tap	65%	253%	390%	42% (of 150%)		
80% tap	80%	384%	480%	64% (of 150%)		
Soft Start	0–100%	0–100%	0–600%	Up to 150%	1. Uses two contactors and solid state power poles. Cost is slightly higher than RVAT.	1. Provides smooth acceleration and deceleration for motors. 2. Heavy duty power section can provide 600% current for 30 seconds or 500% for 60 seconds. 3. Soft stop programmable. 4. Voltage or current ramp programmable. 5. Motor protection and monitoring built into control package. 6. Power poles are individually field-replaceable. 7. NEMA® medium and heavy duty starting in one package.

*Based on assumption that 600% locked rotor currents used for full voltage starting.

Reversing Controllers

Reversing controllers use mechanically and electrically interlocked contactors to swap phases A and C to reverse the direction of the motor. Full voltage reversing controllers (200/400/450 A) are used to control motors being operated in both forward and reverse directions when full-starting torque and resulting inrush current are not a concern for the motor. RVAT and RVSS controllers are also available in reversing configurations.

Sequential Smart Start (S3) Controllers

S3 controllers allow reduced-voltage starting of multiple motors, up to eight, using one RVSS with integrated full voltage starters (FVS) for each motor. Motor protection is provided for both starting and full voltage run modes. This is a cost effective method of starting similar sized motors. Also, you can expect up to a 25% reduction in footprint without the need to overuse multiple reduced-voltage starters for each motor.

Mechanically-Latched Controllers

Mechanically-latched controllers are used for applications where the load remains connected to the power source even during severe undervoltage or power loss conditions. The controller uses a mechanical latching mechanism that holds the contactor closed. Therefore, the load remains connected unless the release is activated either electrically or manually.

Transformer Feeders

Transformer feeders provide a means to control and protect transformers. Mechanically-latched controllers are typically used for this purpose and are supplied with E-rated fuses that are sized for the transformer. Additional protection is available using voltage, current, or multi-function protective relays.

Capacitor Feeders

Motorpact controllers may switch banks of capacitors for a system. Refer to Table 4 for maximum ratings.

Table 4: Maximum Ratings (All Enclosure Types)

Maximum Amps (A)	Voltage (V)	kW	Maximum hp*	Maximum kVA	Maximum kVAR
200	2300	637	854	797	—
400	2300	1275	1709	1593	1500
450	2300	1434	1922	1793	1500
720	2300	2294	3075	2869	2000
200	3300	914	1226	1143	—
400	3300	1829	2452	2286	2000
450	3300	2058	2758	2572	2000
720	3300	3293	4413	4115	2500
200	4160	1153	1545	1441	—
400	4160	2306	3091	2882	2000
450	4160	2594	3477	3242	2000
720	4160	4150	5563	5187	3000
200	6600	1829	2452	2286	—
400	6600	3658	4903	4572	2000
450	6600	4115	5516	5144	2000
720	6600	6584	8826	8230	4000
200	6900	1912	2563	2390	—
400	6900	3824	5126	4780	2000
450	6900	4302	5767	5378	2000
720	6900	6883	9227	8605	4000

* The maximum horsepower values shown here represent approximate motor data. Your maximum horsepower will be dependent on your motors actual efficiency and uncorrected power factor values. Motorpact offers several controller ratings to match your load requirements.

Additional information concerning power factor correction capacitors is provided later in this guide (see page 24).

Prepared Spaces

Prepared spaces are available for future installation of a complete 400, 450, or 720 A full voltage non-reversing (FVNR) controller. These FVNR sections require front and rear access to make it easy to install required components at a later date. The prepared space includes:

- Contactor cradle with line and load stabs
- No-load disconnect with double fuse clips
- Lower fuse tray
- Load connection box
- Low-voltage compartment (without control devices)
- Front doors
- Standard low-voltage control wiring
- Control Power Transformer (same size as other starters in lineup)

Protection Features

Motorpact controllers are built with personal protection in mind. Each unit uses mechanical and electrical interlocks. Mechanical interlocking on the medium-voltage compartment door is engaged when the door is open. It is designed to inhibit the user from accidentally operating the isolation means (IM) handle and energizing the controller with the medium-voltage compartment door open. Interlocking is also provided between the contactor and the IM. This interlock is designed to inhibit the user from operating the IM under load since the switch is a non-load break switch. Mechanical interlocking is also present when the optional earthing switch is present.

The optional **load side** cable grounding switch also contains mechanical interlocking to prevent grounding the load side when the controller is energized.

Voltages

Motorpact controllers are rated for use on systems where the maximum voltage can go as high as 7.2 kV. The following voltages and frequencies are available as standard:

- 2300–2400 V, 50/60 Hz
- 3150–3300 V, 50/60 Hz
- 4000–4160 V, 50/60 Hz
- 4600–4800 V, 50/60 Hz
- 6600–6900 V, 50/60 Hz

Contact your Schneider Electric representative for details on other voltages between 2.3 kV and 7.2 kV.

Heat Losses

Table 5 lists heat loss values.

Table 5: Heat Loss Values for Controllers (Per Vertical Section)

Controller	Heat Loss in Watts
200 A with single barrel fuses (200 FLA)	504 (12R fuse maximum)
400 A with double barrel fuses (400 FLA)	960 (R26 fuse maximum)
450 A with double barrel fuses (450 FLA)	1095 (R38 fuse maximum)
720 A with triple barrel fuses (720 FLA)	1555 (57X fuse maximum)
ADD for MAIN BUS	50 (1200 A)

Environment

Ambient operating temperature range: +23 °F to 104 °F (-5 °C to +40 °C)

Altitude: up to 3300 ft. (1000 meters)

Derating factors apply above 1000 meters. See Table 6 below.

Table 6: General Altitude Adjustment Factors

Altitude	Voltage	Current
3300 ft. (1000 m) and below	1.00	1.00
5000 ft. (1500 m)	0.95	0.99
10,000 ft. (3000 m)	0.80	0.96

Notes:
1. Intermediate values may be obtained by interpolation.
2. For devices used in switchgear assemblies, the standard covering the specific device should be used to determine the correct altitude adjustment factor.

Section 3–Enclosures

Motorpact™ controllers are available in Indoor Type 1/1A (Type 1 with gasket) and Outdoor Type 3R enclosures. Vents and derating are not required for any Motorpact enclosure type.

Indoor Type 1/1A and Outdoor Type 3R enclosure types are defined as follows:

- Indoor Type 1 enclosures are general purpose for use indoors to inhibit accidental contact with the enclosed equipment.
- Indoor Type 1A enclosures are Type 1 enclosures with gasket material added to doors and cover plates. However, the enclosure units are not dust-tight.
- Outdoor Type 3R enclosures are constructed for either indoor or outdoor use to provide a degree of protection against falling dirt, rain, sleet, and snow; and will be undamaged by the external formation of ice on the enclosure.

Construction

Structures consist of a formed steel frame, welded or formed steel doors and side sheets, a flat steel top, and flat steel rear covers. See Table 7 on page 17 for steel gauges. Compartment door latches and hinges are capable of holding the door closed during fault condition. See the “Enclosure and Bus Ratings” table in the Motorpact Medium Voltage Motor Controllers catalog (document no. 8198CT0201). The standard hardware is Grade 5, plated zinc-dichromate.

Arc resistant enclosures, as defined by ANSI C37.20.7, are available as an option. Two types of arc resistant enclosures are offered: Arc Resistant Type 2 Vented and Arc Resistant Type 2 or Type 2B Plenum Style.

Arc Resistant Type 2 Vented is intended to provide a degree of protection from internal arc faults around the perimeter of the equipment. Exhaust vents are provided on the top of the enclosure to vent hot gasses. A minimum of 6.6 ft. (2 m) clearance above the equipment should be maintained.

Arc Resistant Type 2 Plenum Style is intended to provide a degree of protection from internal arc faults around the perimeter of the equipment. Exhaust ports are provided on the top of the enclosure to vent hot gasses to each end of the equipment. This option may be considered when there is 13.2 ft. (4 m) clearance from the bottom of the equipment to any obstruction immediately above OR when the equipment is installed in a Power-Zone™ center. Type 2B Plenum is the same as Type 2 Plenum (described above) except 2B provides additional protection with the low-voltage door open.

Table 7: Steel Gauges Used to Manufacture Motorpact Controllers

Component	Type 1, 1A, or 3R	Arc Resistant
Formed steel frame	11	11
Welded or formed steel doors	11	11
Formed side sheets	11	11
Flat steel top	11	11
Flat back plate	11	11
Flat bottom plates	11	11
Note: 11 gauge or 3 mm thick		

Handling

Controllers are shipped on pallets and can be handled with a fork lift. Each shipping section is also supplied with removable lifting channels or eyes for handling the equipment with a crane. A shipping section may range from one bay, a minimum of 14.75 in. (375 mm) wide, to five bays, a maximum of 73.75 in. (1873 mm) wide. Most shipping sections are less than the 5-bay maximum. Shipping sections can be configured to meet most end users' needs.

NOTE: The autotransformer will be shipped separately for horsepowers above 250. This is done to reduce the overall weight of the controller. The installer will be responsible for the correct installation of the transformer at the job site. For further instruction on the RVAT, see the “Field Installation” section in instruction bulletin no. 46032-700-06.

Contact your Schneider Electric representative for layout details.

Alignment

The enclosures allow for complete front access for installation and servicing. Therefore, the units may be aligned back-to-back or against a wall without impeding access.

Paint

A completely automated and continuously monitored electrostatic powder coat line applies paint. Prior to assembly, one conveyor line moves fabricated steel parts through the pretreatment, coating, and curing process. The overall paint type and process meet the UL 1332 standard for organic coating of steel enclosures for outdoor electrical equipment use.

Table 8: Powder Paint Properties

Property	Description
Color	Medium gray, ANSI® 61 (Munsel 8.3G/6.10/0.54)
Film thickness	1.5–2.5 mil
Cure schedule	30 minutes at 380 °F
Gloss–60 degrees	45%–55% (ASTM D-523)
Hardness	H (min.) on cured film (ASTM D-3363)
Impact resistance	60 inch-pound direct impact (ASTM D-2794)
Humidity	No effect after 1000 hours (ASTM D-2247)
Weathering	Minimum gloss change after 500 hours (ASTM D-822)
Salt spray	1/8 inch creep at 1000 hours (ASTM D-117)

Table 9: Steps for Powder Paint Process

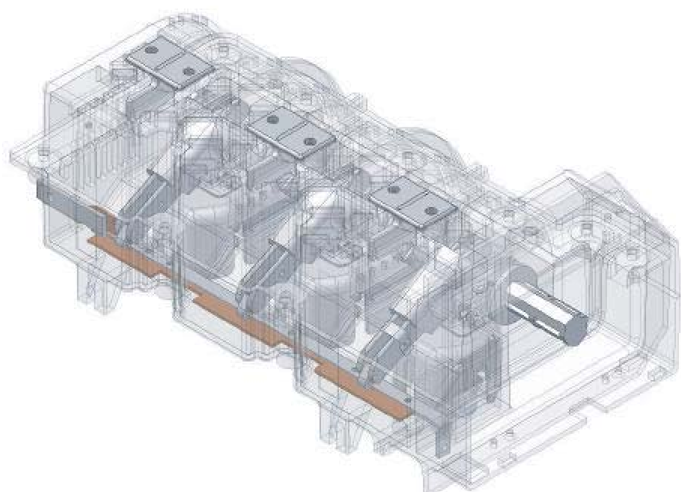
Step	Description
1	Spray de-grease and clean
2	Spray rinse
3	Iron phosphate spray coating
4	Spray rinse
5	Non-chromic seal
6	Oven dry
7	Electrostatic powder spray
8	Oven cure

Section 4–Isolation Means

A means to disconnect a controller from the main power bus is required to allow for maintenance of the units. Each Motorpact™ controller is equipped with an isolation means (IM) like the one shown in Figure 7.

The IM is a medium voltage, three-pole, manually-operated device. In the open position, the IM is grounded.

Figure 7: Isolation Means



Designed for use on systems up to 7.2 kV, the isolation means is rated for continuous 200, 400, 450, and 720 A enclosed. The IMs are non-load break devices, which means the devices cannot interrupt a power load. The isolation means is designed for interrupting the offered control power transformers (CPTs) and voltage transformers (VTs) only.

The mechanical and electrical interlocking described in “Section 2–Controllers” on page 8 inhibits opening or closing the IM with the contactor closed.

Section 5–Contactors

Schneider Electric incorporates state-of-the-art vacuum interrupter technology in all of the contactors. A vacuum interrupter is a switching device that consists of contacts encased in a ceramic envelope that is absent of air. During interruption, the arc vaporizes metal from the surface of the contacts as they separate. The vacuum reduces the intensity of the arc. Therefore the vaporized metal diffuses quickly, dissipating the arc. As the sinusoidal current approaches the next zero current there is no longer enough energy to maintain the arc and the circuit is interrupted.

When the arc is interrupted, there is still a small amount of current that instantly goes to zero. This phenomenon is called “current chopping” and can result in transient over-voltages. Square D brand vacuum interrupters use the latest alloys to reduce problems related to current chopping. However, for very small loads (typically less than 15 A), there is a possibility of higher chopping current and correspondingly higher transient over-voltages. In such cases, surge suppression is recommended.

Standard Motorpact™ contactors are electrically held. The inrush value for the closing coils on 200 A, 400 A, and 450 A contactors is 670 VA. Only 85 VA is required to hold the electrically-held contactors closed. The inrush value for the closing coils on 720 A contactors is 840 VA. Only 120 VA is required to hold the electrically-held contactors closed. They will drop out at or below 50% of nominal voltage.

When applications require the load to remain connected to the source even during severe under-voltage conditions, mechanically-latched contactors are available. Mechanically-latched contactors allow the load to immediately re-energize when power is restored. Motorpact contactors provide, as standard, a manual release as well as an electric release. The electric release does not function when power is lost so an optional capacitor trip unit is available.

Loss of vacuum limits the ability of the interrupter to break a circuit, but this condition is highly unlikely. To minimize the possibility of vacuum loss, periodic dielectric voltage withstand (hi-pot) tests should be performed to detect any deterioration in the interrupter operation. Although the interval between tests depends on the number of operations, environmental factors, and experience, the minimum recommended interval is one year. The hi-pot test follows the ANSI®/IEEE Std. 4-1978 for dielectric withstand tests (see Table 11 for field test hi-pot test voltages).

AC test units are not always available in the field, so a dc test is acceptable. However, a good interrupter may have unacceptable results during a dc hi-pot test due to microscopic anomalies that may appear between the contacts. These anomalies are due to the vaporized metal that forms the arc. AC tests burn away anomalies, allowing the interrupter to function properly during hi-pot. DC half-wave rectified hi-pot test units should be avoided since they greatly increase the possibility of x-ray emissions. Refer to the “Installation” section of instruction bulletin 46032-700-06 before conducting any tests on the contactor.

Table 10: Design/Manufacturer Hi-Pot Test Values

Equipment Maximum Rating (kV)	Design/Manufacturer Test Values	
	AC (kV)	DC (kV)
2.4	7.4	10.5
3.3	9.5	13.5
4.2	11.4	16.1
4.8	12.8	18.1
5	13.3	18.8
5.5	14.4	20.4
6	15.5	21.9
6.6	16.9	23.9
6.9	17.6	24.9

Table 11: Field Test Hi-Pot Test Values

Equipment Maximum Rating (kV)	Field Test Values	
	AC (kV)	DC (kV)
2.4	5.5	7.9
3.3	7.1	10.1
4.16	8.5	12.1
4.8	9.6	13.6
5	10	14.1
5.5	10.8	15.3
6	11.6	16.4
6.6	12.7	17.9
6.9	13.2	18.7

Table 12: Contactor Selection

Continuous Current	Contactor Rating
Up to 200 A	200 A
201–400 A	400 A
401–450 A	450 A
451–720 A	720 A

Table 12 shows contactor selection based on the continuous current. The continuous current includes the service factor of the motor. Service factor indicates the ability of the motor to operate above the motor rating. For example, a motor rated for 100 A full load with a service factor of 1.15 may operate with a full load current of 115 A without damage to the motor.

Table 13: Contactor Technical Data

Contactor Ratings	200 A, 400 A, and 450 A	720 A
Rated Voltage	2400–6900 V (7.2 kV max.)	2400–6900 V (7.2 kV max.)
Operational Current	200 A, 400 A, 450 A	720 A
Interrupting Current		
Unfused	5000 A	7200 A
Fused	50,000 A	50,000 A
Short Time Current		
30 seconds	3000 A	4300 A
1 second	7500 A	10,800 A
Peak Withstand Current	85 kA	85 kA
Switching Frequency	1200/hour (300/hour latched)	600/hour (300/hour latched)
Mechanical Life	2.5 M (250 K latched)	1 M (200 K latched)
Electrical Life	250 K	200 K
Impulse Withstand	60 kV	60 kV
Dielectric Strength	22 kV–1 minute	22 kV–1 minute
Closing Time	7 cycles (60 Hz)/6 cycles (50 Hz)	7 cycles (60 Hz)/6 cycles (50 Hz)
Opening Time	2 or 18 cycles (60 Hz)/2 or 15 cycles (50 Hz) (dependent on fuse size)	4 cycles (60 Hz)/4 cycles (50 Hz) (additional delays may be required to coordinate with fuses)
Arcing Time	0.6 cycles or less	0.6 cycles or less
Pick-up Voltage	85% (hot)/40% (cold), AC or dc	85% (hot)/40% (cold), AC or dc
Drop-out Voltage	50% (hot)/40% (cold), AC or dc	50% (hot)/40% (cold), AC or dc
Tripping Voltage (Latched)	Less than 60% of coil rating dc (cold)	Less than 60% of coil rating dc (cold)
Control Voltage		
Standard	120 VAC, 50/60 Hz	120 VAC, 50/60 Hz
Optional	240 VAC/125 Vdc/250 Vdc	240 VAC/125 Vdc/250 Vdc
Control Circuit Burden		
Closing	670 VA	840 VA
Holding	85 VA	120 VA
Tripping Voltage (Latched)	4.8 A (dc) max.	4.8 A (dc) max.
Auxiliary Contact Rating		
Current	10 A (A600)	10 A (A600)
Voltage	600 V max./48 V min.	600 V max./48 V min.
AC	720 VA (P.F. 0.35)	720 VA (P.F. 0.35)
dc	60 W (L/R 150 ms)	60 W (L/R 150 ms)
Environmental Conditions		
Altitude Without Derating	3300 ft. (1000 m)	3300 ft. (1000 m)
Ambient Temperature	-5 to +40 °C	-5 to +40 °C
Relative Humidity	45 to 85%	45 to 85%
Vibration	20 Hz – 1 G	20 Hz – 1 G
Shock	30 G	30 G

Section 6–Fuses

Interrupting ratings for Motorpact™ controllers are shown in Table 13 on page 20. NEMA now classifies these types of controllers as non-fused or fused. Motorpact controllers are available for fused applications only.

For currents higher than the contactor ratings, fuses are added to the controller. The fuses are coordinated with the contactor to interrupt the higher currents before the contactor opens. The fuses provide short circuit protection for current levels above the contactor rating. In some cases, depending on fuse size, additional contactor opening time delays have to be configured in the protective relay using its definite time function. To maximize the time delay further, the protective relay’s inverse time curves could be used (if properly coordinated with fuse curve).

The fuses are retained in fuse clips mounted on the isolation means and on the lower fuse tray. This component-to-component configuration reduces heating by minimizing connection points.

Proper fuse selection requires some basic load data that depends on whether the controllers are used for motor starting or feeder disconnect applications.

Motor Starting Applications

Motor starting applications use R-rated fuses, which contain two elements. The first element provides short circuit protection while the second element provides overload protection via an inverse-time delay. The inverse-time delay element allows the motor to accelerate (*i.e.,* operate at 600% of full load for a short period of time). Current limiting fuses are designated as R-rated if they meet the following requirements per ANSI® C37.46:

- The fuse interrupts all currents between its minimum and maximum interrupting ratings.
- The fuse will melt within 15 to 35 seconds at 100 times the R number.

Fuse selection is based on the following motor data:

- Full-load current
- Locked-rotor current
- Acceleration time

This information is required at the time of order entry to properly process and engineer the order.

Feeder Disconnect Applications

Feeder disconnect applications use E-rated fuses which provide over-current protection for the load. Current limiting fuses are designated as E-rated if they meet the following requirement per ANSI C37.46:

> The current responsive element shall melt in 300 seconds at an rms current within the range of 200% to 240% of the continuous current rating of the fuse, fuse refill, or link.

Fuse selection is based on the following load data:

- kVA rating
- System voltage

This information is required at the time of order entry to properly process and engineer the order.

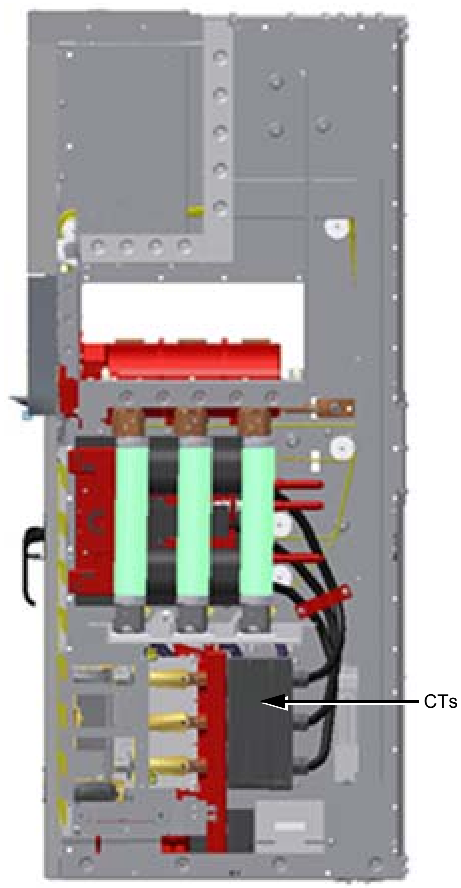
Section 7–Power Components

Motorpact™ controllers are equipped with current transformers and control power transformers with options available such as voltage transformers, power factor correction capacitors, surge arresters, and surge capacitors.

Current Transformers

Current transformers (CTs) are used to provide a current at an acceptable level (typically 0–5 A) to metering, protective, and control devices. Figure 8 shows the three-phase CT (center) and the ground fault current transformer (GFCT, lower right). These devices are toroidal or donut type CTs. Toroidals are used for phase CTs. This type of CT is less intrusive in the circuit and allows ratio adjustments to be made.

Figure 8: A 3-Phase CT and GFCT Mounted in a Controller



Phase CT output is proportionate to the current flowing in a particular phase as shown in the following example:

Motor full load current = 78 A

CT ratio = 100:5 (20)

CT out = 78/20 = 3.9A (at full load)

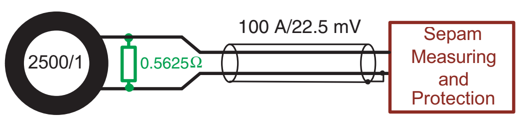
The input on the primary of the CT is 78% of the CT primary rating (or 100 A), and the output of the secondary is 78% of the 5 A secondary rating, (or 3.9 A).

Motorpact controllers use 600 V voltage class CTs. Use of this lower voltage class is possible since the cable through the toroid is insulated and the cable insulation provides the insulating properties required. CT accuracy is shown in Table 14 on page 23.

Table 14: CT Accuracy

Catalog Number	Current Ratio (Amps)	ANSI® Relay Class	ANSI Metering Class at 60 Hz	IEC Relay Class	IEC Metering Class at 60 Hz	Resistance	
			80.1	80.2	80.5	80.9	81.8
3PL55-50C	50:5	—	5.0	—	—	—	—
3PL55-101	100:5	—	2.4	—	—	—	—
3PL55-151	150:5	—	1.2	2.4	—	—	—
3PL55-201	200:5	—	1.2	1.2	2.4	2.4	—
3PL55-251	250:5	—	0.6	0.6	1.2	2.4	—
3PL55-301	300:5	—	0.6	0.6	1.2	1.2	—
3PL55-401	400:5	—	0.3	0.3	0.6	1.2	1.2
3PL55-501	500:5	C10	0.3	0.6	0.6	1.2	—
3PL55-601	600:5	C10	0.3	0.3	0.6	1.2	2.4
3PL55-751	750:5	C10	0.3	0.3	0.3	0.6	1.2
3PL55-801	800:5	C10	0.3	0.3	0.3	0.6	1.2
3PL55-10	1000:5	C10	0.3	0.3	0.3	0.3	0.6
3PL55-12	1200:5	C20	0.3	0.3	0.3	0.3	0.6

Figure 9: LPCT Diagram



Ground fault CTs are used to measure the level of current going directly to ground. The output is used by either a ground fault or multi-function relay to provide protection. Typically, a 50:5 CT is used, but both 100:5 and 2000:1 versions are available upon request. The 2000:1 GFCT is usually reserved for high-resistance grounded systems requiring greater sensitivity.

Low powered current transformers (LPCTs) are also used to measure rated currents between 100 and 1250 A with a ratio of 100 A/22.5 mV. The LPCT is used when a Sepam relay is provided for motor protection. The benefit of this form of CT is that it will work at up to 1250 A continuous on the primary, allowing the same LPCT to be used through the full current range of the Motorpact™ offering.

Voltage Transformers

Relays or meters sometimes require three-phase voltage to operate. This voltage is supplied in one of the following ways:

- A single 100 VA three-phase voltage transformer (VT)
- Voltage transformer section
- Three-phase wire bus

The 100 VA three-phase voltage transformer is typically supplied unless a higher burden is required. This VT is mounted on the floor of the starter behind the contactor rail assembly.

For higher burden requirements, a VT section may be supplied. The section contains two VTs wired in open delta or three VTs wired in a Wye configuration along with the primary and secondary fuses. The VT switch and VTs are mounted in this enclosure.

It is possible to use one VT section for a line-up and distribute the power via a wire power bus. For some applications, a three-phase wire bus may be advantageous. This method requires mounting the VTs remotely and feeding the controller or line-up with a potential bus (see “Section 8–Bus” on page 25).

Power Factor Correction Capacitors

A majority of the total load connected to industrial power systems is inductive and has a low operating power factor. This type of load results in poor electrical efficiency, higher electrical costs, and extra burden on the power system. Properly selected and installed power factor correction capacitors (PFCCs) provide an economical means of improving system power factor. Table 15 shows the estimated PFCC size in kVAR for a motor, based on horsepower and speed. Capacitors must be carefully sized when switched with a motor since overvoltages and transients may occur if the capacitor kVAR exceeds the motor magnetizing current.

Please note the following:

- The motor manufacturer determines the maximum kVAR value for the motor.
- Appropriate kVAR size is dependent on system parameters.
- Schneider Electric can only supply estimated kVAR size based on the motor horsepower unless a system study is performed.
- PFCCs mounted at the motor will affect the full load current seen by the Motorpact™ controller. The motor nameplate full load current must be recalculated based on the improved power factor and the overload settings must be adjusted accordingly.
- PFCCs should always be connected to the line side of autotransformers and soft starts.

Table 15: Estimated PFCC Selection Based on Motor Horsepower and Speed

HP	Nominal Motor Speed (RPM)											
	3600		1800		1200		900		720		600	
	kVAR	%AR▲	kVAR	%AR▲	kVAR	%AR▲	kVAR	%AR▲	kVAR	%AR▲	kVAR	%AR▲
100	25	7	25	10	25	10	25	11	25	12	25	17
150	25	7	25	9	25	9	25	10	50	11	50	15
200	25	7	25	8	50	8	50	9	50	11	50	15
250	50	7	50	6	50	8	50	9	75	10	75	14
300	50	7	50	5	75	5	75	9	75	10	100	14
350	50	6	50	5	75	5	75	9	75	9	100	12
400	50	5	50	5	75	5	100	9	100	9	100	11
450	75	5	50	5	75	5	100	8	100	9	100	10
500	75	5	75	5	100	5	125	8	125	8	125	8
600	75	5	100	5	100	5	125	7	125	8	125	8
700	100	5	100	5	100	5	125	7	150	8	150	8
800	100	5	125	5	125	5	150	7	150	8	150	8
900	125	5	200	5	200	5	200	6	250	7	250	7
1000	150	5	250	5	250	5	250	6	250	7	250	7
1250*	200	5	250	5	250	5	300	6	300	6	300	6

▲ The %AR value is the percent ampere reduction required for the overload setting when PFCCs are connected after the overload protective device, such as at the motor. PFCCs in Motorpact™ controllers are connected ahead of the overload so this reduction is not required. **Always connect PFCCs to the line side of autotransformers and reactors.**

* If horsepower is above 1250, please call Schneider Electric's customer support (1-888-778-2733).

The following is additional information that should be considered when using PFCCs in a line-up of Motorpact controllers.

Harmonics

All capacitors are a low impedance path for harmonic currents produced by non-linear loads such as variable frequency drives, motor soft starters, welders, computers, PLCs, robotics, and other electronic equipment. These harmonic currents can be drawn into the capacitor, causing it to overheat, shortening its life, and possibly preventing proper operation. Furthermore, the resonant circuit formed by the capacitor in parallel with the system inductance (transformers and motors) can magnify harmonic currents and voltages, which can cause nuisance fuse operation and/or damage electrical equipment.

Back-to-Back Capacitor Switching

Multiple fixed motor capacitor applications located on the same bus can produce potentially damaging high inrush currents. The worst-case scenario is realized when all capacitor banks are energized and the final uncharged bank is closed. Because of very low impedance of the uncharged capacitor, a large magnitude, high-frequency inrush current will flow from each charged capacitor bank into the switched bank. These inrush currents may cause the capacitor fuse to blow. To reduce back-to-back inrush current stress, current limiting (inrush) reactors need to be used. An alternative solution would be centralized automatic capacitor banks.

Surge Protection

Lightning or switching may cause surge voltages that can damage a motor. The surge can be limited by using two methods, either individually or together.

A surge arrestor (SA) is a protective device that limits surge voltages by diverting the surge current. The SAs are only operational when a predetermined voltage level is reached. At that time, the device activates and diverts the current to ground through a resistance, therefore clamping the voltage at a safer level.

Two classes of surge arrestors are available in Motorpact™ line-ups:

- Distribution class: used to protect a single device with a pressure relief of about 10 kA.
- Station class: used to protect more than one device and provide the highest degree of protection, energy handling level, and pressure relief capability (80 kA or more).

A fast-rising surge voltage at the motor terminals may cause severe voltage stress to the turn-to-turn insulation of the motor windings. The fast rise can be limited by connecting a surge capacitor to the motor terminals. The charging rate slows the rise of the surge voltage, thus reducing the stress on the winding insulation.

The optimum mounting location for surge protection is at the motor terminal box. This limits the lead length to 1–2 ft. (0.3–0.6 m). However, surge protection can be mounted in Motorpact controllers. In this case, the layout is dependent on the equipment and options selected. Consult your Schneider Electric representative for layout assistance.

Section 8–Bus

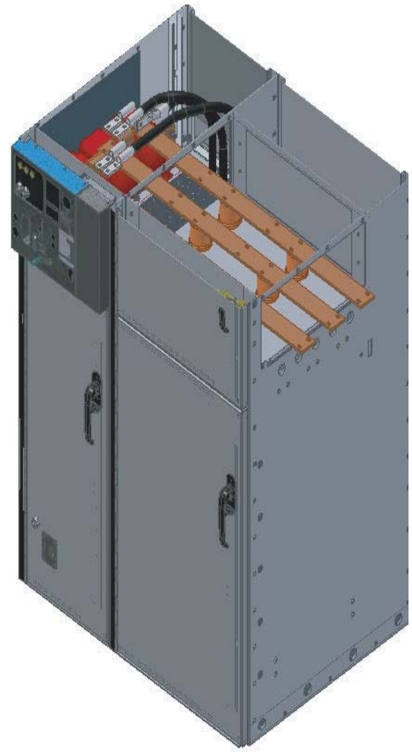
Each Motorpact controller or line-up can have four types of bus provided:

- Power
- Ground
- Potential
- Control power

Power Bus

Figure 10 on page 26 shows the power bus in the bus compartment. In this figure, the top and side panels of the bus compartment are removed and the vertical bus and wire ways are visible.

Figure 10: Power Bus



When power bus is required for a Motorpact™ controller, the bus is attached to the top of the isolation means that is located in the enclosure. This mounting isolates the power bus inside the controller, allowing maintenance or line-up extension without disassembling the controller.

Power bus for Motorpact controllers consists of non-tapered copper bus rated for 600, 1200, 2000, or 3000 A. The correct rating for your application depends on the loads to be supplied. All power bus is tin-plated as standard with silver plating as an option. When required, a heat shrink PVC jacket insulation is available.

Ground Bus

A ground bus is provided in all Motorpact controller bays. The standard bus is unplated copper and is tested at 50 kA for 1 second. Options include:

- Tin plating
- Ground lugs

Potential Bus

At times, due to cost or convenience, a voltage source can be supplied for metering or relaying purposes via a potential bus. A potential bus is appropriately-sized wire connected between controllers, allowing for a single potential source rather than a source in each unit. The potential bus is routed through each controller’s low-voltage compartment.

Control Power Bus

The control power transformer can be omitted from a controller, allowing customers to supply their own power from a separate source. To accommodate this, Motorpact controllers can be configured with a control wire bus. This bus consists of appropriately-sized wires with terminal connections for customer use.

Section 9–Low-Voltage Components

Motorpact™ controllers are provided with a 120 V control circuit. Typical circuits may contain some or all of the following:

- Pilot devices
- Control relays
- Protective devices
- Monitoring devices
- Wiring devices

The configuration and quantity of each component depends on the controller type and customer requirements.

Figure 11: Low-Voltage Components Mounted to the Relay Panel

Pilot Devices

Square D™ Class 9001 Type XB pilot devices are normally used, but other devices in the Square D Digest can be provided. Each controller is supplied with the following standard pilot devices:

- Momentary START push button
- Momentary STOP push button
- Red RUN pilot light (LED)
- Green OFF pilot light (LED)

Control Relays

A minimum of one relay is furnished with each controller to provide an interposing relay to the contactor. Telemecanique™ IEC-style relays have four 10 A-rated contacts and have optional instantaneous or timed contact blocks available. NEMA®-rated relays are available but may be limited by space constraints. Contact your Schneider Electric representative for details.

Protective Devices

Protective devices are selected to provide the level of protection for the motor required by the application. Selection of the appropriate device may require monitoring specific parameters or several parameters. Motorpact™ controllers have many options available for protection including current, voltage, and multi-function relays.

Current Relays

Along with the current relays listed below, overcurrent, undercurrent, current unbalance, and differential current relays are also available. Contact your Schneider Electric representative for details.

NOTE: Other third party protective relays are available.

LRD Overload Relay

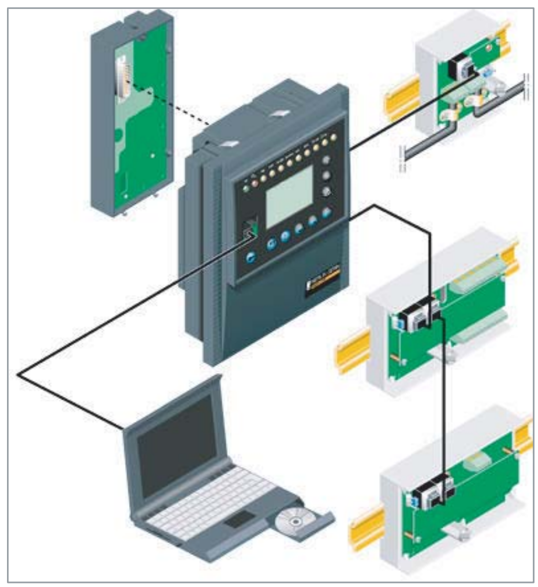
This relay is an ambient compensated bi-metallic device and is an option for motor protection in Motorpact controllers.

Sepam

This solid state relay protects a motor from overloads (ANSI®/IEEE Device 49/51), plus it provides:

- Phase loss protection
- Unbalance protection (ANSI/IEEE Device 46)
- Class II ground fault protection
- Switch-selectable trip class

Figure 12: Sepam Relay



Ground Fault Sensor

The ground fault sensor detects changes in the leakage current by monitoring the phasor sum of the phase currents. When the leakage current reaches a level preset by the user, the relay trips.

Voltage Relays

Voltage relays monitor the voltage to the motor terminals to detect variations that may damage the motor windings. Relays are available to monitor for undervoltage, overvoltage, voltage unbalance, frequency, phase loss, or phase reversal. Contact your Schneider Electric representative for details.

Multi-Function Relays

Solid state relays are available that are flexible with several protective functions. These relays are programmable and allow the user to select the protection required for a particular application. Protective functions include:

- Overload (ANSI®/IEEE Device 49/51)
- Phase reversal (ANSI/IEEE Device 47)
- Unbalance (ANSI/IEEE Device 46)
- Ground fault (ANSI/IEEE Device 50G/51G)
- Locked rotor (ANSI/IEEE Device 50S)
- Starts per hour (ANSI/IEEE Device 66)
- Time between starts
- Bearing/winding over-temperature (ANSI/IEEE Device 49/39)
- Undercurrent (ANSI/IEEE Device 37)

PowerLogic™ Monitoring Systems

PowerLogic power monitoring systems provide the power monitoring and control solutions needed to manage today's complex industrial, commercial, and utility electrical systems. PowerLogic provides colorful, easy-to-use displays that combine real-time operational data with stored plant parameters, making electric plant operation simpler and more efficient. PowerLogic systems range from stand-alone circuit monitors, capable of replacing over 50 indicating meters, to complete systems providing real-time and historical data, time trend plots, alarms, power quality analysis, data logging, output control, and more.

Figure 13: PowerLogic Circuit Monitor

Web-Enabled Equipment

Motorpact™ controllers with PowerLogic circuit monitors, Sepam relays, and Web-enabled Ethernet communication devices are a part of the web-enabled equipment offer from Schneider Electric. Web pages are a standard feature of the reduced-voltage soft start controllers.

When specified as web-enabled equipment, the Motorpact controllers are provided with a factory-configured “plug and play” communications system that allows the authorized user access to equipment status and monitoring information using a standard Web browser.

Figure 14: Web-Enabled Equipment

Networking Options

Web-enabled equipment is available in two different communication configurations. Both provide access to your power equipment via a PowerLogic™ Ethernet interface.

- Ethernet Communications Card (ECC): Web-enables your PowerLogic circuit monitor and provides web-based access to downstream-connected devices. Equipment with an ECC includes a bonus web page with real-time metering data for the host circuit monitor.

Figure 15: CM4000 with Ethernet Communications Card

Figure 16: Front-Accessible Ethernet Connection and EGX Ethernet Gateway with DIN Rail Mount

- Ethernet Gateway (EGX): Features an embedded web server and provides web-based access to downstream-connected devices. Equipment using an EGX includes a front-accessible Ethernet connection to help make commissioning easy.

Metering and Monitoring Devices

At the heart of the web-enabled equipment offer is an assortment of Schneider Electric products. You can tailor a system to precisely meet your needs by purchasing the devices that provide the system data you desire. Table 16 details the functionality supported by web-enabled equipment and the corresponding devices.

Whether a unit substation, an MCC, or stand-alone switchgear, web-enabled equipment provides real-time information at any time, from anywhere, to any authorized user easily.

Table 16: Functionality Supported

	Micrologic™ P Trip Unit	Micrologic™ A Trip Unit	Sepam Series 40, 80	Sepam Series 20	Motor Logic Plus™ Overload	Altivar™ 58 and 66 Drives	Altistart™ 46 and 48 Soft Starts	Motorpact™ Soft Start Relay	Model 98 Temp. Controller	CM4000 Circuit Monitor	PM800 Power Meter
RMS Current 3-Phase Average (Amps)	■	■	■	■	■	■	■	■		■	■
Real Power (kW)	■		■							■	■
Power Factor	■		■							■	■
Circuit Breaker Status (Open/Closed)	■	■	■	■							
Motor Control Device Status	■	■			■	■	■	■	■		
Fan Status (ON/OFF)									■		
Transformer Coil Temperature (°C)									■		
Drive Output Frequency (Hz)						■		■			
Thermal Capacity (%)					■	■	■	■			
RMS Current, Phases A, B, & C (Amps)	■	■	■	■						■	■
Average Demand Current, Phases A, B, & C (Amps)	■		■	■						■	■
Present Demand (kW)	■		■							■	■
Peak Demand (kW)	■		■							■	■
Date/Time Peak Demand Recorded	■		■							■	■
Energy (kWH)	■		■							■	■
Reactive Energy (kVARH)	■		■							■	■
Date/Time Energy & Reactive Energy Values Last Reset	■		■							■	■

Wiring Devices

Wiring devices used in Motorpact™ controllers are shown in Table 17.

Table 17: Wiring Devices

Device	Description
Control wire	16 and 14 gauge, TFFN/THHN, black insulation
CT circuit wire	12 gauge AWM molded into CTs Optional: 10 gauge THHN in low-voltage compartment only
Terminal blocks	**CT circuit:** Shorting terminal blocks are available **Customer connections:** 600 V, 30 A compression-box style; accepts up to #10 AWG **Internal terminal block connections:** 600 V, 20 A spring-cage style; accepts up to #12 AWG **Internal harness connections:** 300 V, 10 A spring-cage style
Wire markers	Slip-on sleeve type (heat shrinkable)

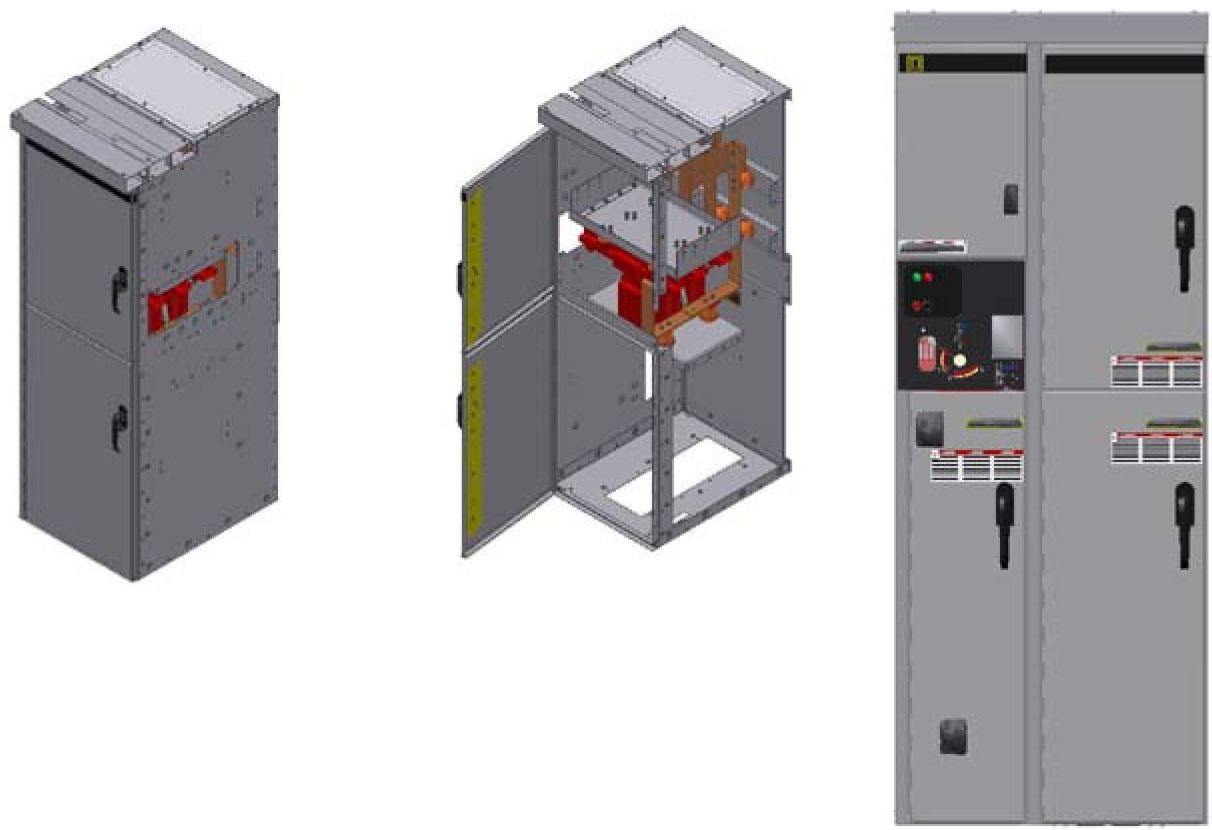
Section 10–cULus Labeling

cULus labels are available as standard for Motorpact controllers.

Section 11–Incoming Line Terminations

The versatile Motorpact line provides the user with many power connection options. Power may be supplied to a Motorpact controller or line-up using cable or bus.

Figure 17: Incoming Line Sections



Cable Connections

Motorpact™ controllers provide incoming cable termination points for cables using compression lugs. The compression lugs themselves are available as an option. The termination points are configured for NEMA® 2-hole drilling with 1/2 in. hardware to inhibit cable rotation. Cable connections are made to the following:

- Isolation means
- Incoming line section

For all Motorpact controllers connected to an isolation means, the top and bottom entry cables are limited to 1-750 MCM or 2-500 MCM for 450 A and 2-750 MCM for 720 A. Space is provided for prefabricated stress cones only. Stress cones are not supplied by Schneider Electric.

Maximum cable ranges with options are shown in Table 18.

Table 18: Maximum Cable Ranges With Options

Incoming Entry	With Metering CTs	With Lightning Arresters	With Live Line Indicators	Maximum Cables per Phase	Maximum Cable kcMIL (Shielded)	Pull Box	Section Width
Bottom		✓	✓	4	1000	N/A	20 in. (500 mm) or 29.50 in. (750 mm)
Bottom		✓		4	1000	N/A	20 in. (500 mm) or 29.50 in. (750 mm)
Bottom			✓	4	1000	N/A	20 in. (500 mm) or 29.50 in. (750 mm)
Bottom				4	1000	N/A	20 in. (500 mm) or 29.50 in. (750 mm)
Bottom	✓	✓	✓	6	750	N/A	20 in. (500 mm) or 29.50 in. (750 mm)
Top	✓	✓	✓	4	500 (see note 6)	17 in. (432 mm)	29.50 in. (750 mm)
Top		✓	✓	6	500	10 in. (254 mm)	29.50 in. (750 mm)
Top		✓		6	500	10 in. (254 mm)	29.50 in. (750 mm)
Top			✓	6	500	10 in. (254 mm)	29.50 in. (750 mm)
Top		✓	✓	6	750	17 in. (432 mm)	29.50 in. (750 mm)
Top		✓		6	750	17 in. (432 mm)	29.50 in. (750 mm)
Top			✓	6	750	17 in. (432 mm)	29.50 in. (750 mm)
Top				6	4/0	No	29.50 in. (750 mm)

1. Sections can be configured for 1200, 2000, or 3000 A main bus.
2. Top Entry/Exit is restricted when enclosure is Arc Resistant construction.
3. All 3000 A main bus sections require a 10 in. (254 mm) vent box on top that can be used as a pull box. A 17 in. (432 mm) high pull box may be used for additional cable space.
4. This table is based on shielded cables with 8.0 kV prefabricated stress cones. Larger diameter unshielded cables may be used in some cases.
5. N1 gasket enclosures require any 10 in. (254 mm) high pull box to be sized to 17 in. (432 mm).
6. 500 kcMIL when a conduit entry. 750 kcMIL when an overhead cable tray. (Restriction based on cable bending radius due to CT.)

Bus Connections

Direct bussing to other MV equipment is accomplished by one of the following options:

- Bus transitions: Standard transition sections are available to directly bus Motorpact controllers to Masterclad™, HVL™, HVL/cc™, VisiVac™, and Model 4 motor controllers.
- Bus duct connection: Bus duct connections to Motorpact controllers are accomplished via a special bus compartment.

See "Appendix B–Elevation Views" on page 47 for typical elevation views.

Section 12–Load Cable Terminations

Motorpact™ controllers provide complete front access to the load termination points. Similar to the incoming power cable connections, the load cable connections are designed for compression type lugs. Compression lugs are available as an option through Schneider Electric. The termination points have NEMA® 2-hole drilling with 1/2 in. hardware to inhibit cable rotation. Space is available for prefabricated stress cones, but they are not supplied by Schneider Electric. Because of some limited space applications, Schneider Electric recommends 3M® Quick Term II stress cones.

For all Motorpact controllers using shielded cable with or without stress cones, the cable is limited to 1-500 MCM or 2-250 MCM for 450 A and 1-1000 MCM or 2-750 MCM for 720 A for both top and bottom entry.

Section 13–Load Break Switch

For applications that require a load break switch, the Motorpact line offers the HVL and HVL/cc Load Break non-fused and fused switches. Rated at either 600 A or 1200 A continuous, these switches have the same footprint as the Motorpact controllers. Transitions may be required to Motorpact controllers. The switch can be located on either end of the lineup or in the middle as a tie switch for main-tie-main applications. HVL switches are used for 61 kA applications and HVL/cc switches are used for 40 kA applications.

Configurations depend on the switch application. HVL and HVL/cc switches may be used for either feeder or incoming line applications. Feeder switches provide a manual means of breaking a transformer circuit. Incoming line switches provide both a termination point for incoming cables and a disconnecting means. Both configurations may be supplied non-fused or with E-rated fuses. Fuse clips are provided for fuses up to 450E and bolted fuses are used above 450E. Table 19 and Table 20 list the construction possibilities.

Table 19: HVL and HVL/cc Switch Ratings

Load Break Switch	Switch Width	Maximum Voltage (kV)	BIL Rating (kV)	Continuous Current (A)	Momentary Current Asymmetrical (kA)	Current Symmetrical (kA)	Fault Current Closing Asymmetrical (kA)
HVL	38 in. (965 mm)	5.5	60	600	40	25	40
	38 in. (965 mm)	5.5	60	1200	61	38	61
	38 in. (965 mm)	7.2	60	600	40	25	40
	38 in. (965 mm)	7.2	60	1200	61	38	61
HVL/cc	14.75 in. (375 mm), 20 in. (500 mm), 29.50 in. (750 mm)	5.5	60	600	40	25	40
	29.50 (750 mm)	5.5	60	1200	40	25	40
	14.75 in. (375 mm), 20 in. (500 mm), 29.50 in. (750 mm)	7.2	60	600	40	25	40
	29.50 (750 mm)	7.2	60	1200	40	25	40

Table 20: Integrated Short Circuit Ratings for HVL and HVL/cc with E-Rated Fuses

Equipment Maximum Rating (kV)	Short-Circuit Current Rating in RMS Symmetrical Amperes (kA)	Maximum MVA Rating (MVA)
2.3	50	199
	40	159
	25	100
3.3	50	286
	40	229
	25	143
4.16	50	360
	40	288
	25	180
6.6	50	572
	40	457
	25	286
6.9	50	598
	40	478
	25	299

Line cable termination points for incoming line switches are located in the cell closest to the cable entry point and the switch is mounted in the opposite cell. For example, a top entry switch has the termination points in the top cell and the switch is mounted in the bottom cell.

Another application for HVL and HVL/cc switches is main-tie-main. This configuration requires special bus arrangements and key interlocks. The key interlocks inhibit accidental entry to live components. Each switch can house up to six key interlocks in either the ON or OFF positions. Consult your Schneider Electric representative for main-tie-main details.

Just like Motorpact™ controllers, the HVL and HVL/cc switches have many protective features:

- The switch is mechanically interlocked to:
  - Inhibit opening the door with the switch closed
  - Inhibit closing the switch with the door open
- A screen is provided behind the door to inhibit direct access to the switch components with the door open.
- Each switch is provided with a viewing window for visible confirmation of switch position.

Options for incoming switches include:

- Metering (requires CTs and/or PTs)
- Surge arresters
- Surge capacitors

Some options may limit cable access. Refer to the appropriate product technical data for HVL and HVL/cc. The ratings for the HVL/cc switch are shown in the appropriate pricing guide.

Fuse curves for both E-rated and R-rated fuses are available through the Schneider Electric web site (www.schneider-electric.us).

Section 14–Estimated Structure Weights

Table 21 shows the estimated structure weights.

Table 21: Estimated Structure Weights

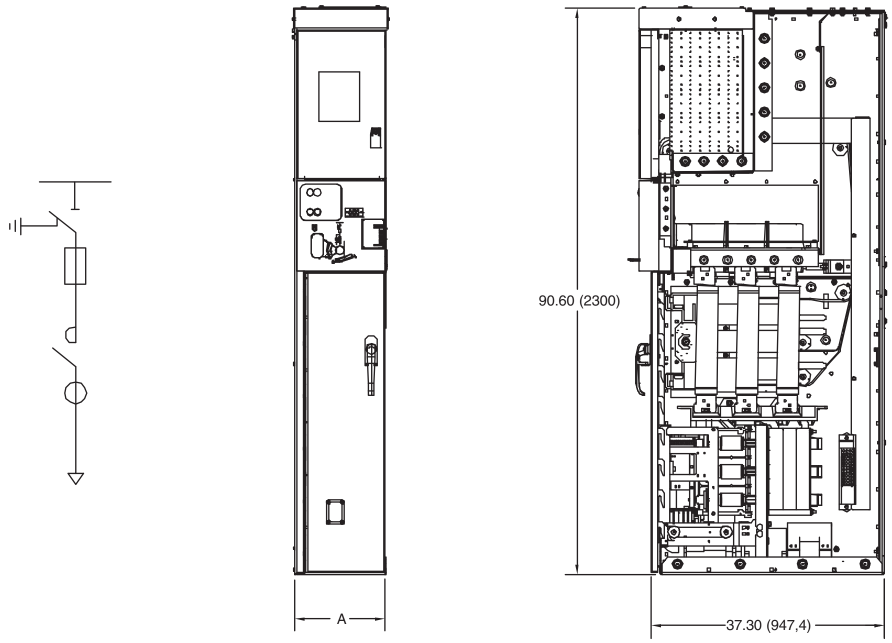
Type	Description	Weight ▲ ■
Across-the-line controller	200/400 A, 14.75 in. (375 mm) wide	1150 lb. (523 kg)
	400 A, 20 in. (500 mm) wide	1250 lb. (567 kg)
	400 A, 29.50 in. (750 mm) wide	1500 lb. (680 kg)
	450 A, 20 in. (500 mm) wide	1250 lb. (567 kg)
	720 A, 29.50 in. (750 mm) wide	1500 lb. (680 kg)
Autotransformer controller	200/400 A (two structures)	3600 lb. (1633 kg)
	450 A (two structures)	3800 lb. (1727 kg)
RVSS controller	200/400 A (two structures)	3000 lb. (1364 kg)
	450 A (two structures)	3100 lb. (1409 kg)
Outdoor Type 3R Weight Additions		
Controller/Incoming Line	29.50 in. (750 mm) wide	310 lb. (141 kg)
RVAT/RVSS	59 in. (1498.60 mm) wide	640 lb. (291 kg)
RVAT	73.75 (1873.25 mm) wide	795 lb. (361 kg)
	88.50 (2248 mm) wide	950 lb. (432 kg)
Empty box		350 lb. (159 kg)

▲ Includes main power bus.

■ Weight does not include end sheets. Add 90 lbs. per end unit where applicable; two end sheets required per lineup.

Appendix A–Outline Drawings

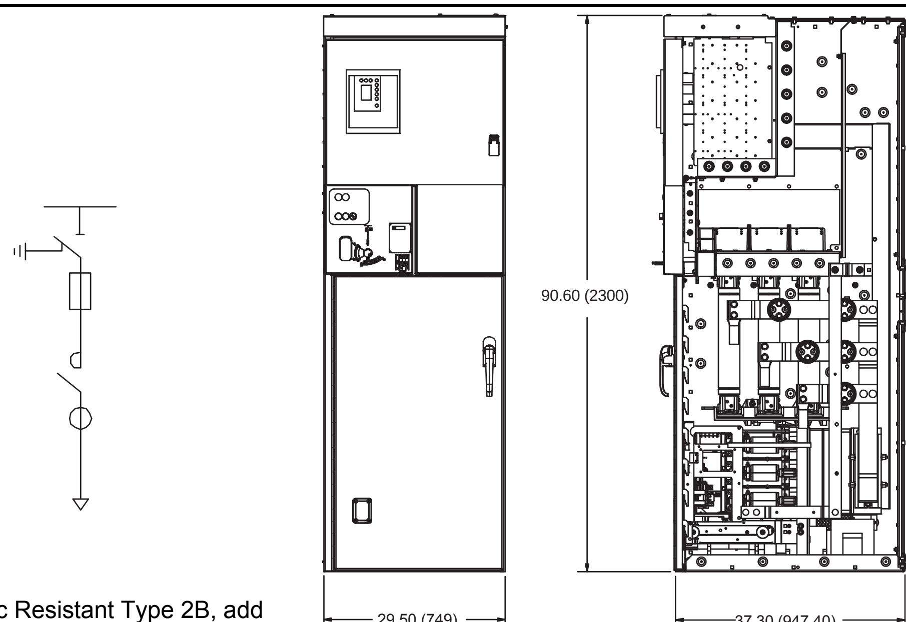
Figure 18: 200 A–450 A FVNR Controller Bay



	A Cabinet Width (In./mm)
Enclosure 375	14.75/375
Enclosure 500	20/500
Enclosure 750	29.50/749

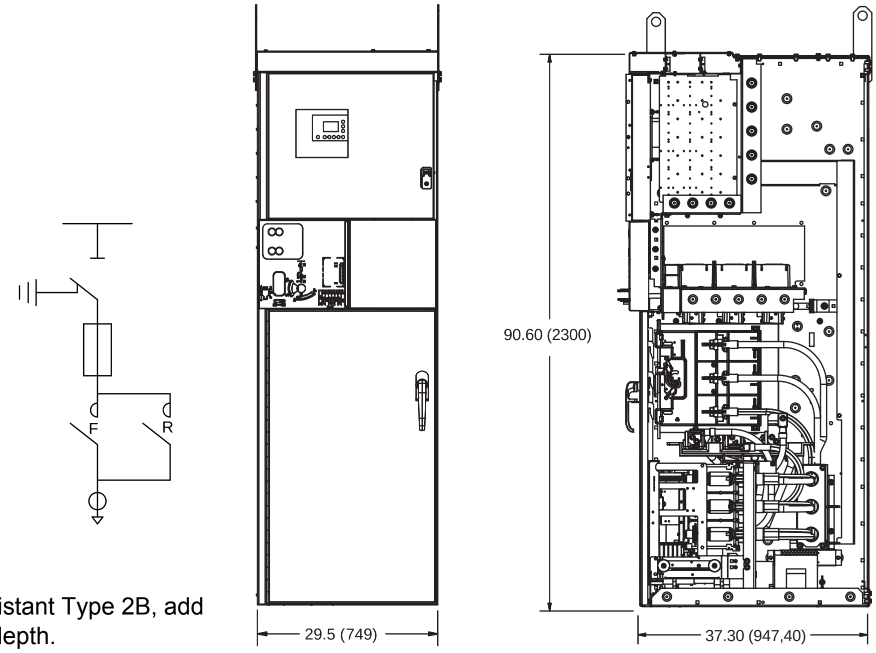
NOTE: For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.

Figure 19: 720 A FVNR Controller Bay



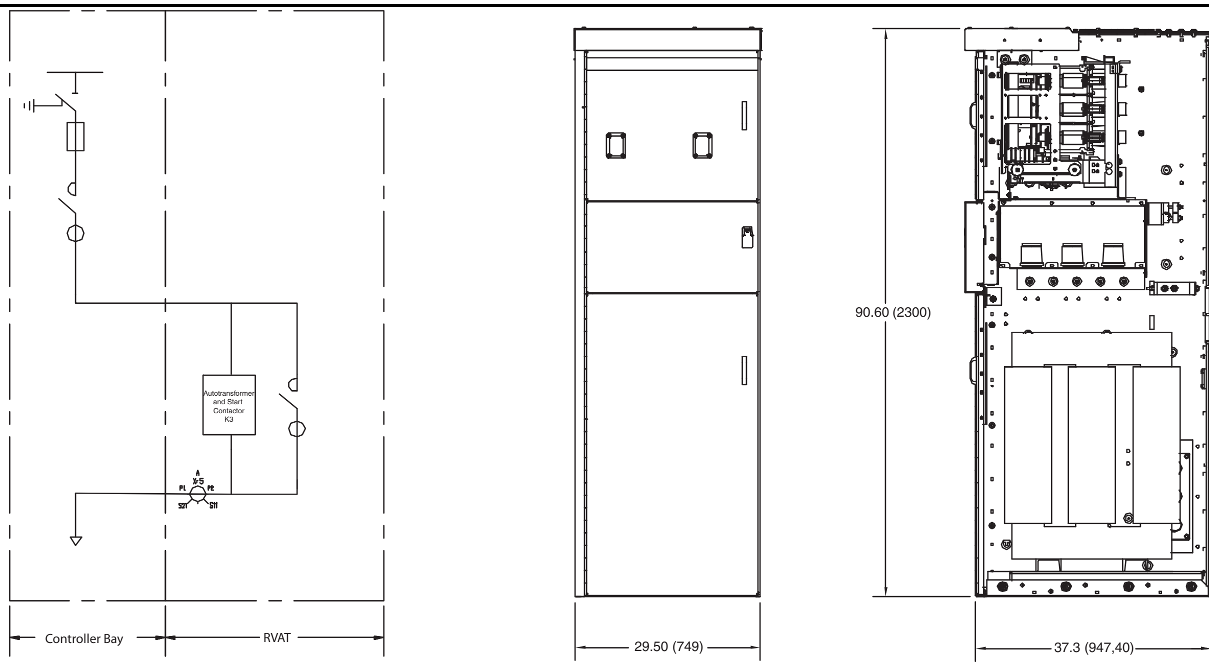
NOTE: For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.

Figure 20: 200, 400 and 450 A FVR Controller Bay



NOTE: For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.

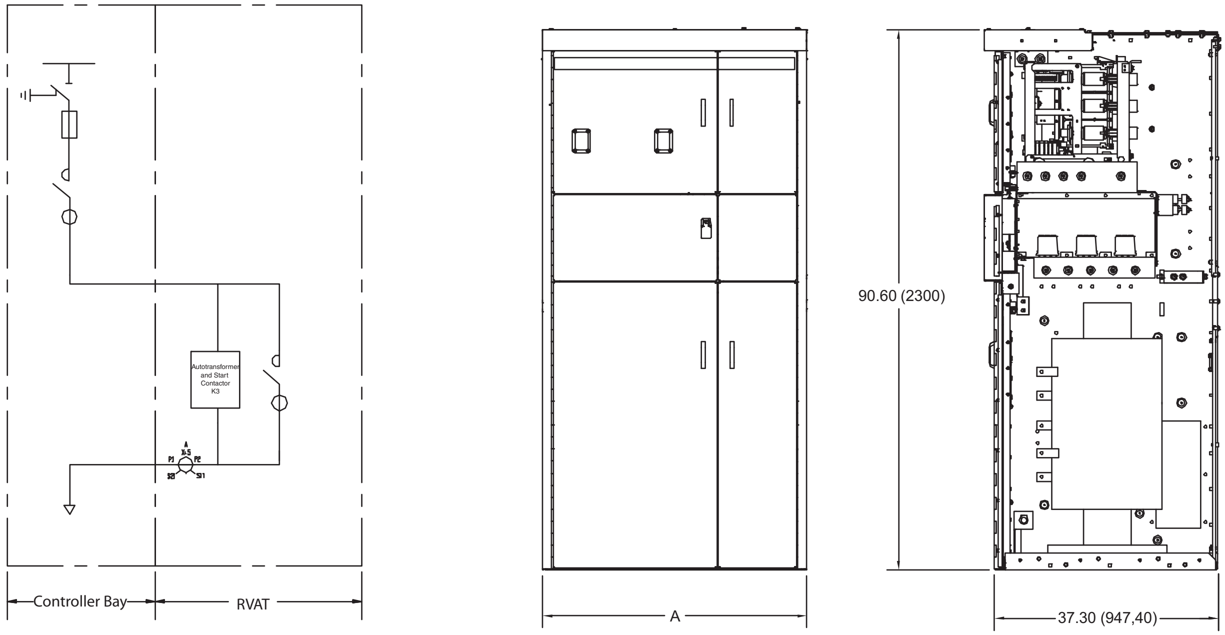
Figure 21: Reduced-Voltage Autotransformer (Smallest Auxiliary Section)



NOTES:

- For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.
- The total controller bay expands based on the options selected. See Figure 18 for additional controller bay dimensions.

Figure 22: Reduced-Voltage Autotransformer

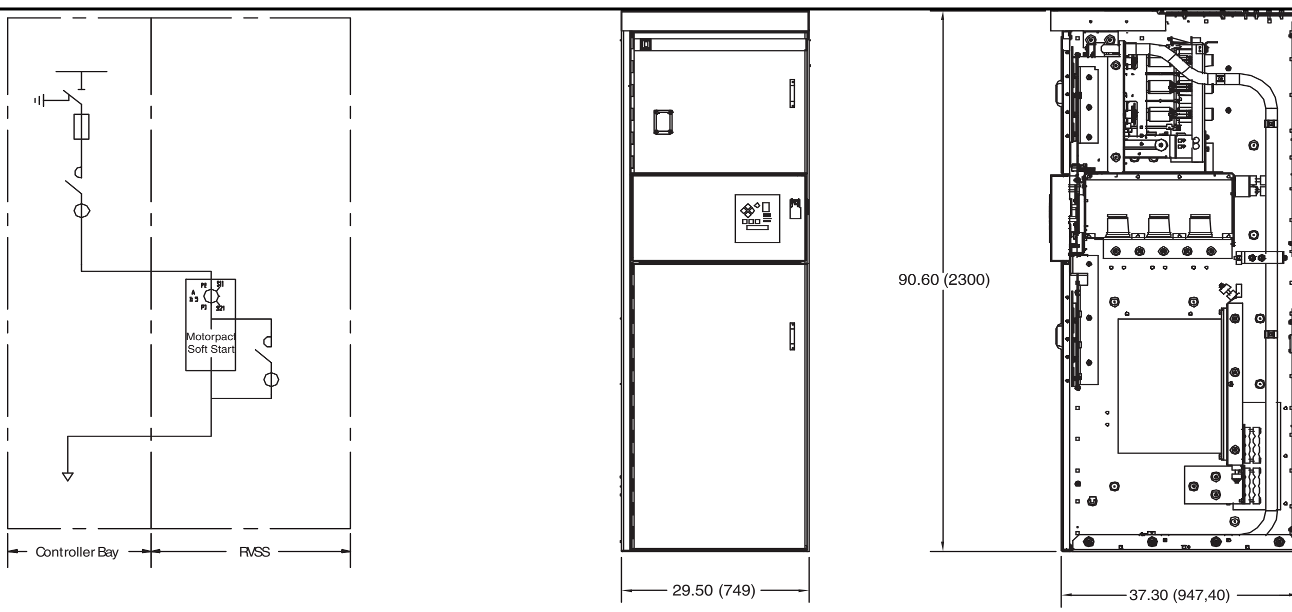


	A Cabinet Width (In./mm)
Enclosure 1125	44.25/1124
Enclosure 1500	59/1498.6

NOTES:

- For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.
- The total controller bay expands based on the options selected. See Figure 18 for additional controller bay dimensions.

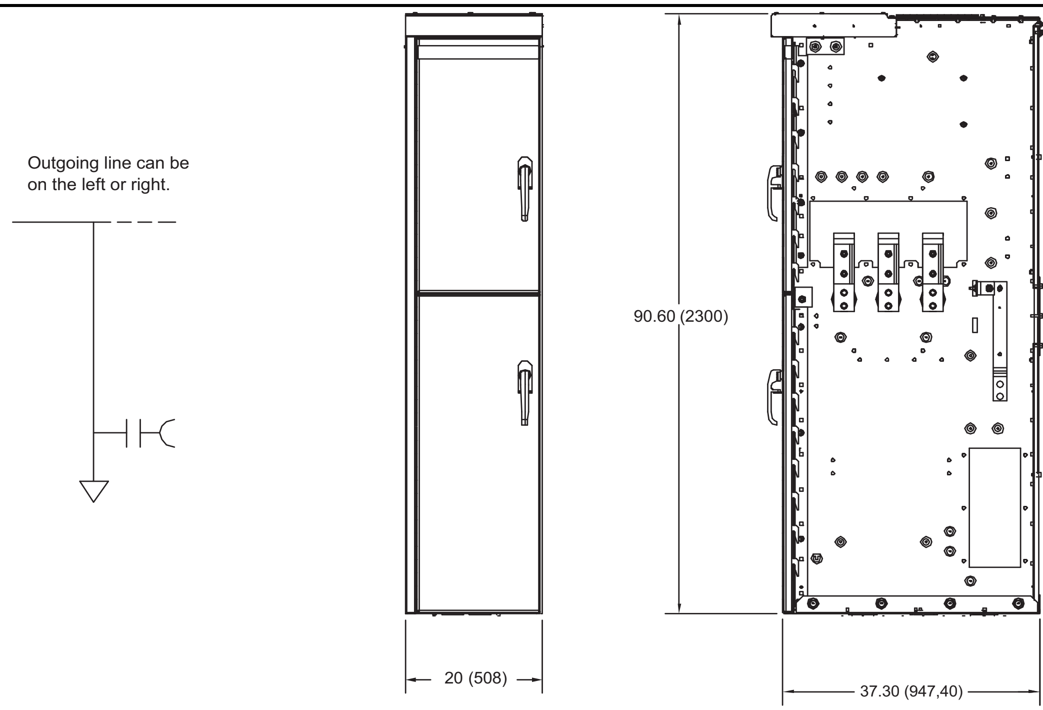
Figure 23: Reduced-Voltage Soft Start



NOTES:

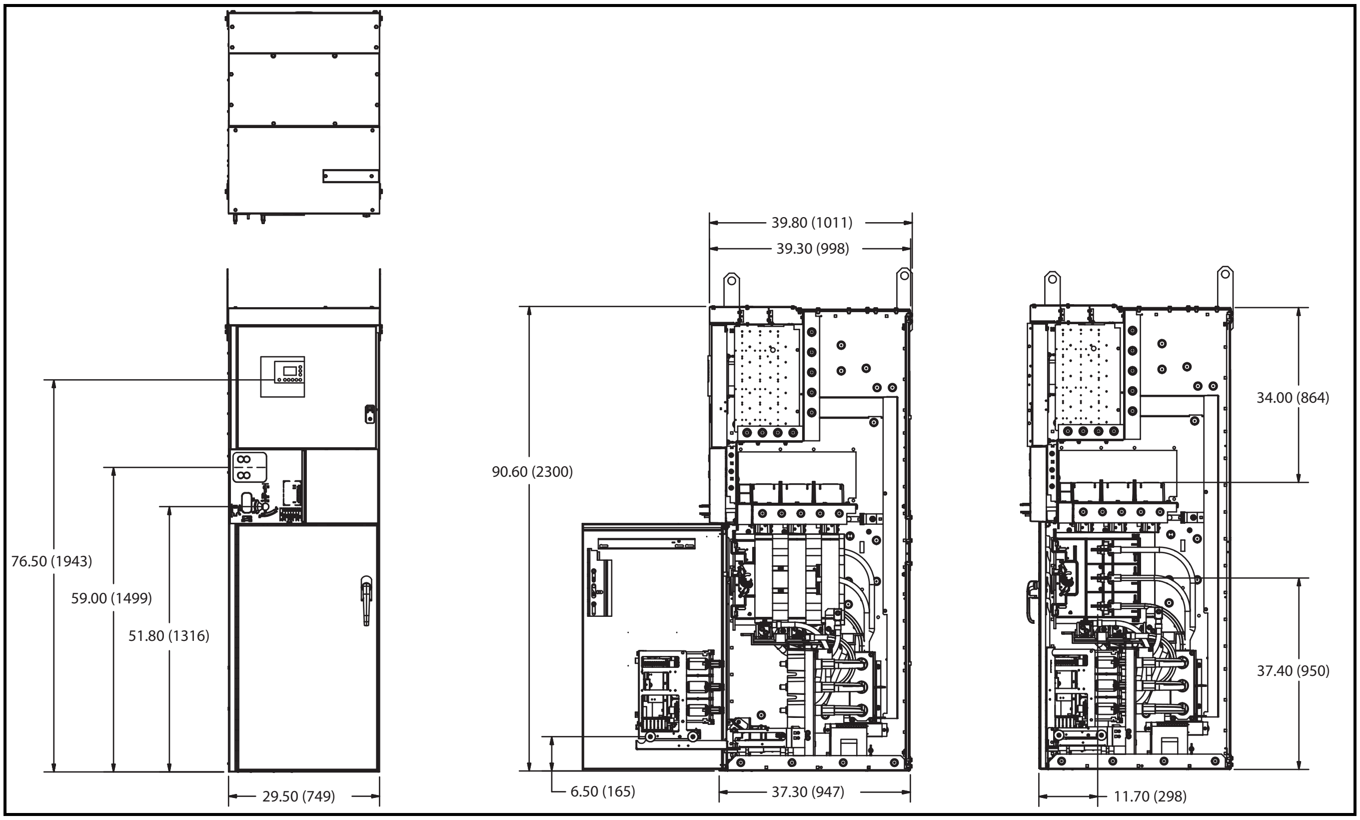
- For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.
- The total controller bay expands based on the options selected. See Figure 18 for additional controller bay dimensions.

Figure 24: Enclosed 20 in. (500 mm) Incoming Bay (Bottom Entry)



NOTE: For Arc Resistant Type 2B, add 11 in. (279 mm) to depth.

Figure 25: Typical 450 A Two-Speed, One-Winding and Two-Speed, Two-Winding Motor Controllers—Indoor



Type 3R Outdoor Top and Floor Plan Drawings

Figure 26: Type 3R FVR/FVNR Controller

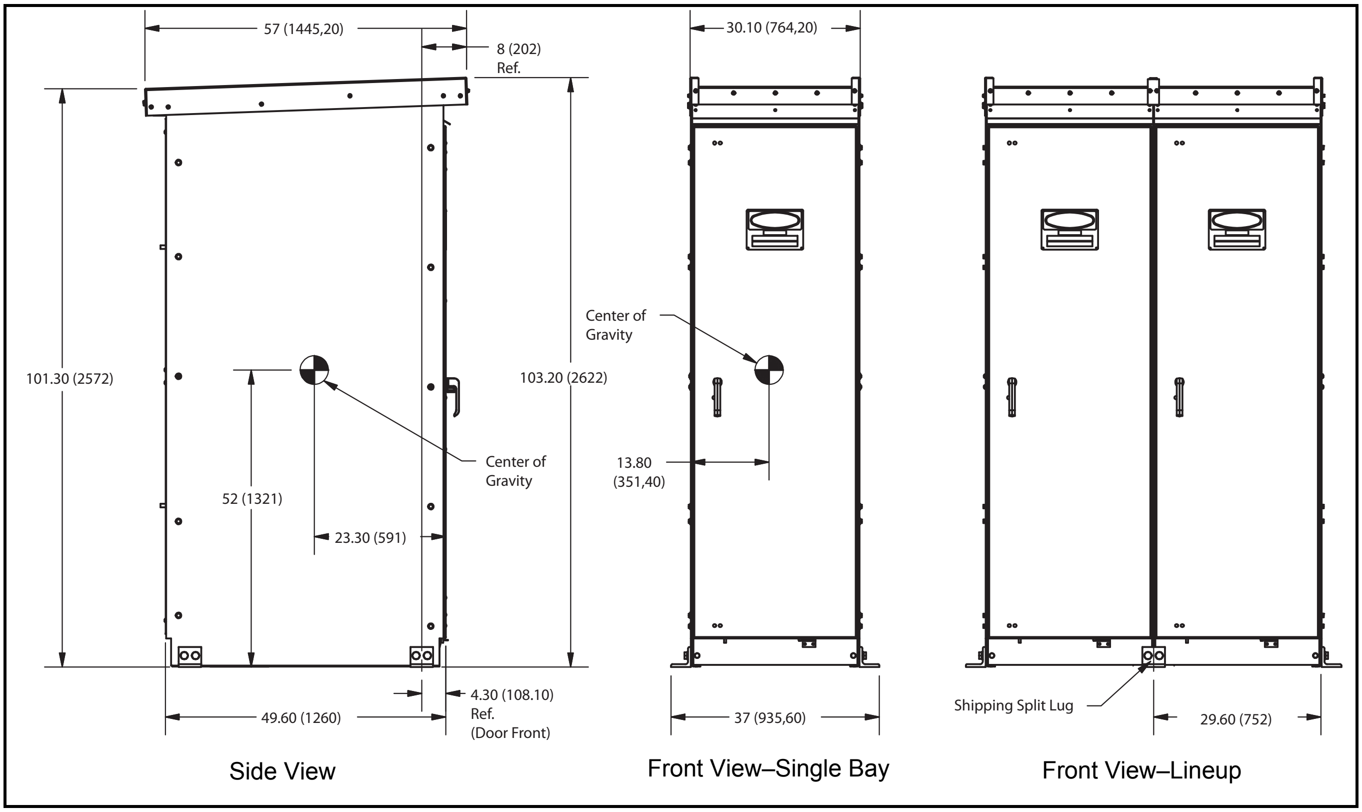


Figure 27: Type 3R 450 and 720 A Controllers, Plan View

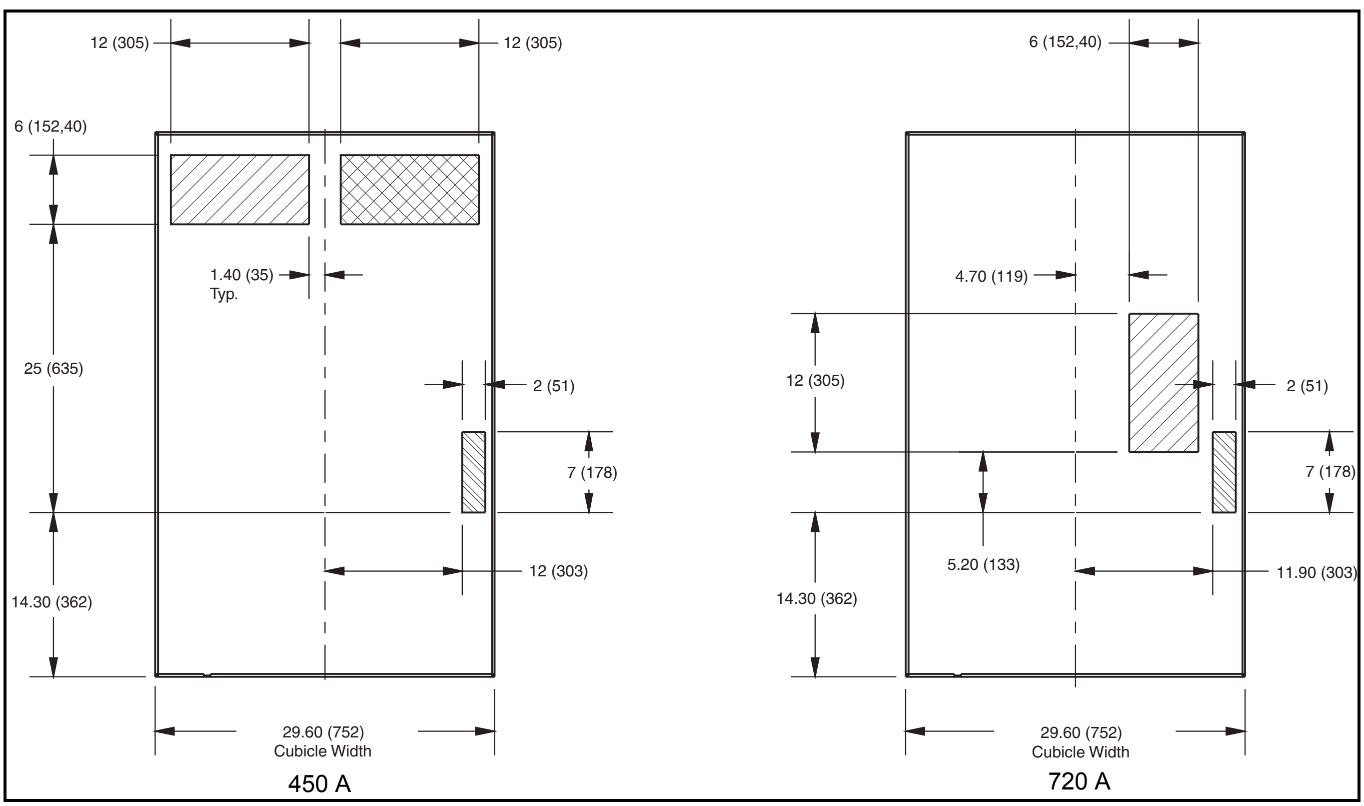


Figure 28: Type 3R Controllers, Incoming and Auxiliary Sections

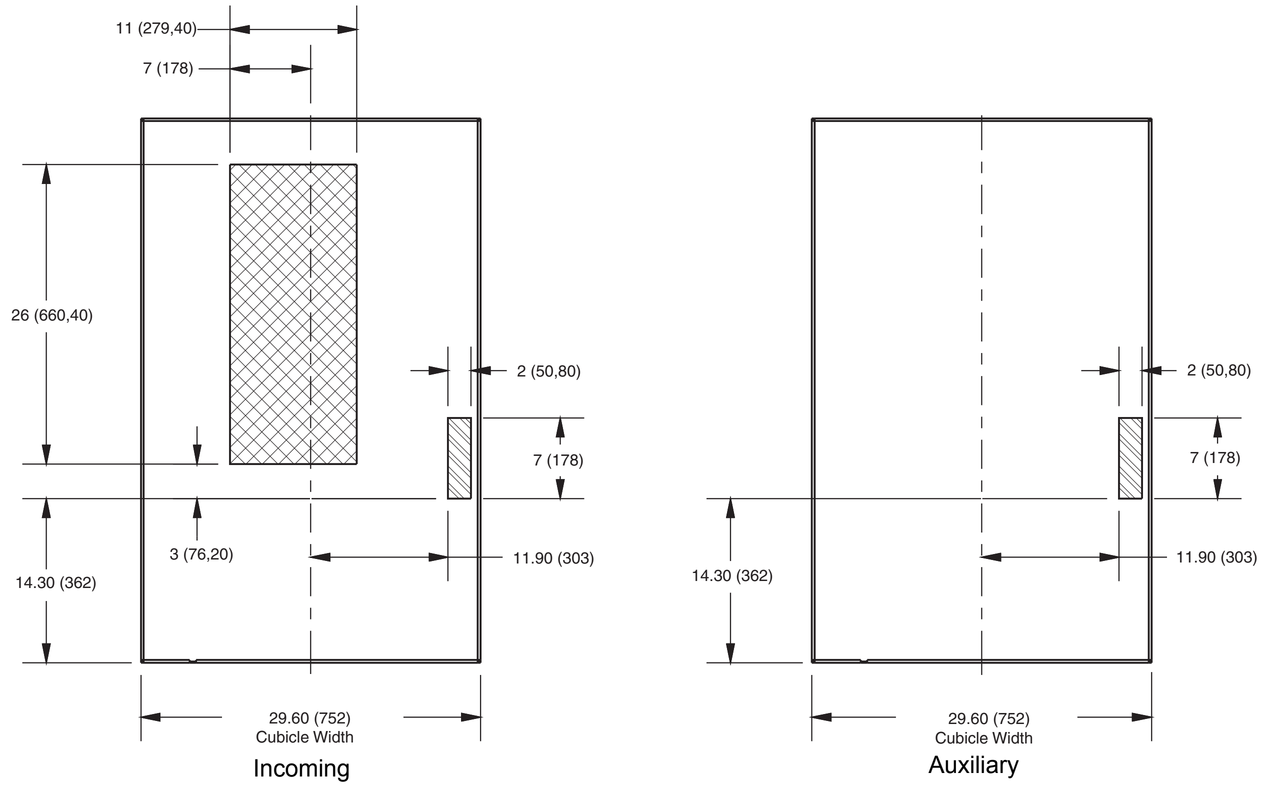


Figure 29: Type 3R RVAT/RVSS Side View

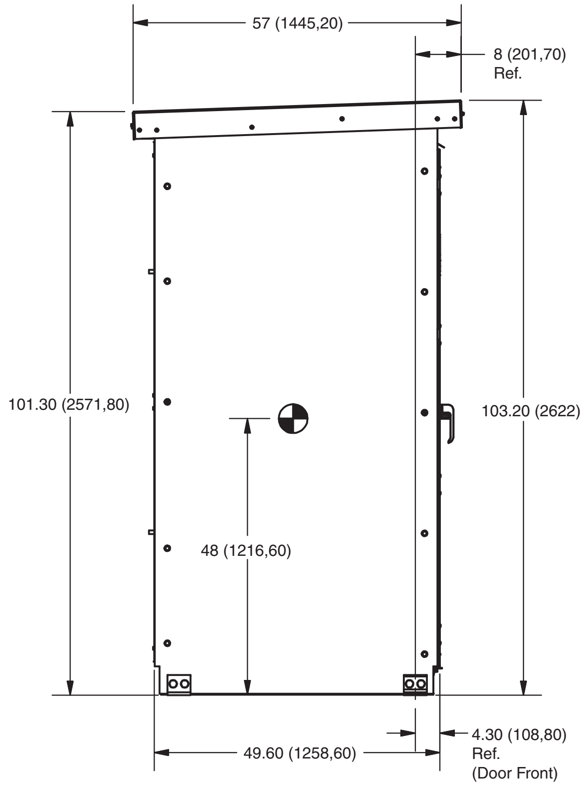


Figure 30: Type 3R RVAT/RVSS Front View, 29.50 In. (749 mm) Wide

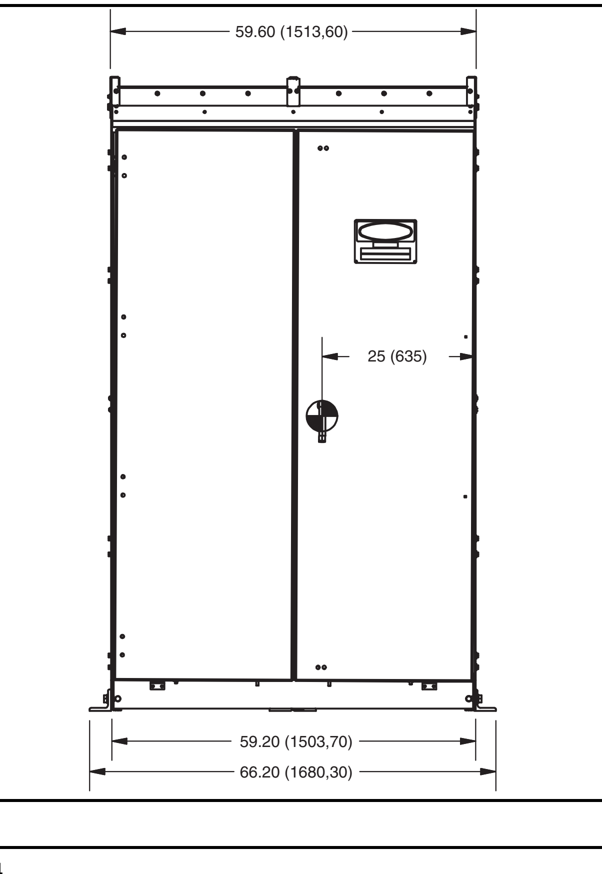


Figure 31: Type 3R RVAT Front View, 44.25 (1125 mm) Wide

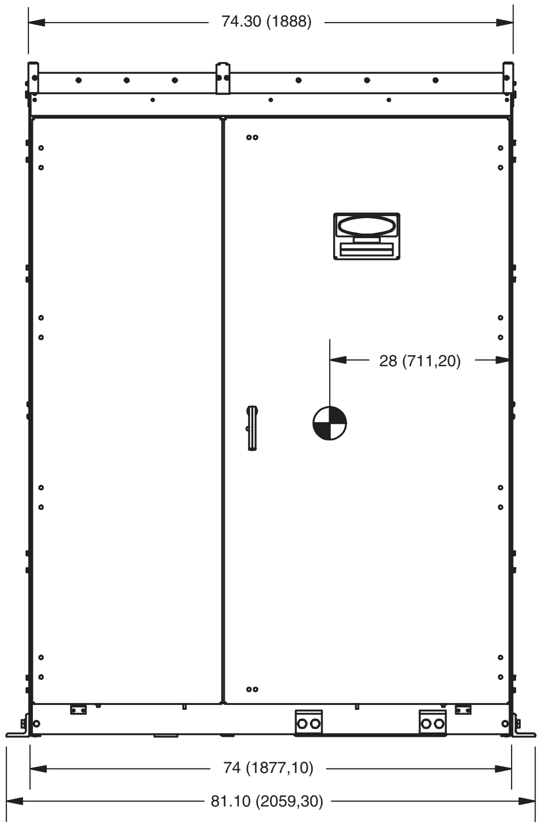
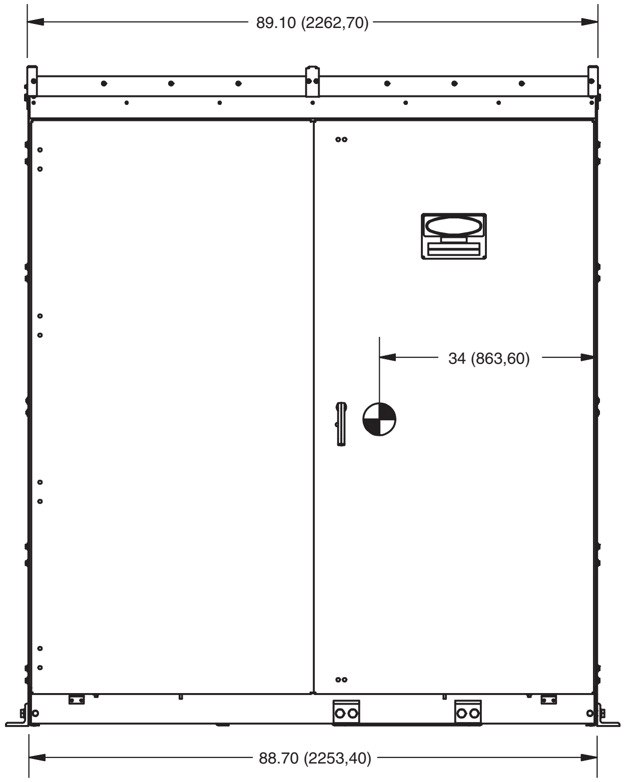
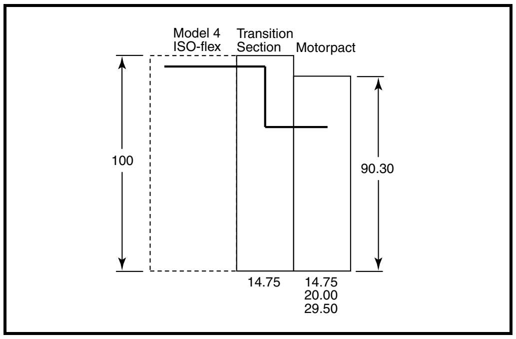


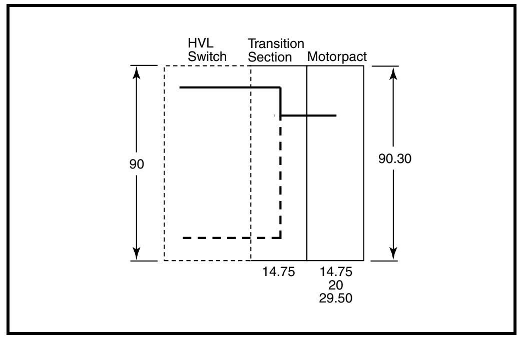
Figure 32: Type 3R RVAT Front View, 59.00 (1500 mm) Wide



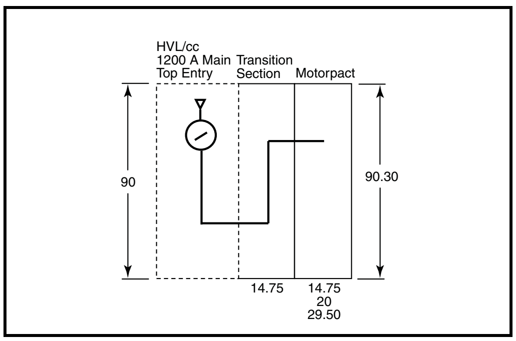
Appendix B–Elevation Views



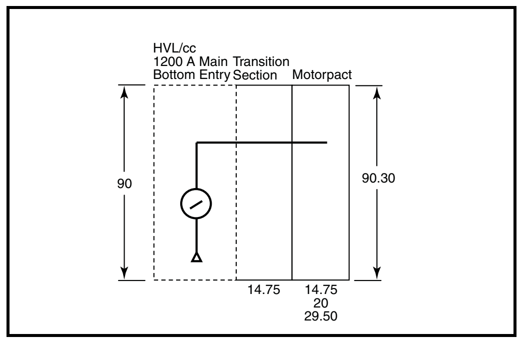
Elevation View — Model 4 ISO-flex™



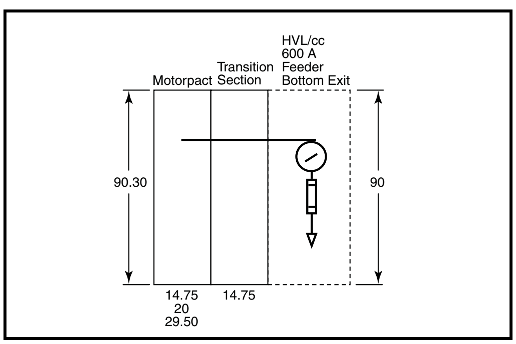
Elevation View — HVL Switch



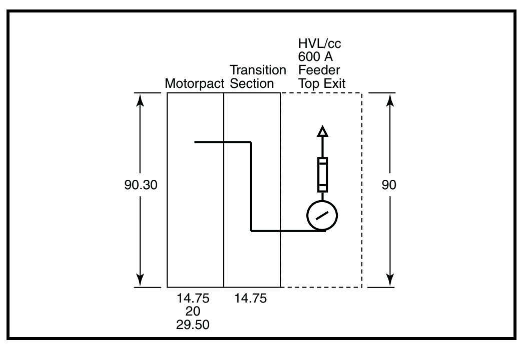
Elevation View — HVL/cc Main — App A



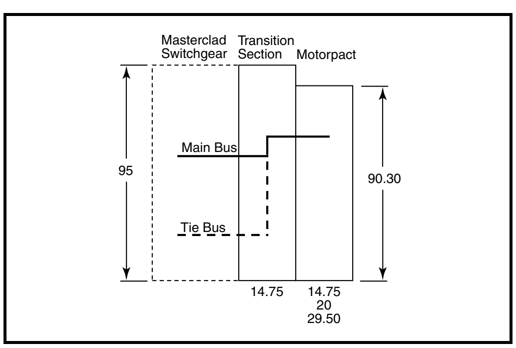
Elevation View — HVL/cc Main — App B



Elevation View — HVL/cc Feeder — App A



Elevation View — HVL/cc Feeder — App B



Elevation View — Masterclad™

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